# Seasonal Patterns of Biological and Physical Variables in Sediments of Lime Kiln Bay during 2000-2001

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## ABSTRACT

Wildish, D.J., Akagi, H.M., and Martin, A. 2002. Seasonal patterns of biological and physical variables in sediments of Lime Kiln Bay during 2000-2001. Can. Tech. Rep. Fish. Aquat. Sci. 2447: iii + 46 p.

During the period from September 2000 to September 2001 we conducted monthly sediment interfacial and profile sampling at two stations within Lime Kiln Bay. This Bay has been utilized for salmon culture since 1981. Station R was seaward of a bar, which separated the two basins within the Bay and station E was located in the inner, landward basin. Both stations were close to salmon lease sites, but were >100 m away from cages and so were not exposed to direct, near-field deposition (waste food, salmon faeces) from the cages. Reported here are the monthly results for redox, total sulfide, chlorophyll a, phaeophytin, enzymatically hydrolyzable amino acids, sediment interfacial temperature, sediment profile imaging and macrofaunal community characteristics, for stations R and E.

## RÉSUMÉ

Wildish, D.J., Akagi, H.M., and Martin, A. 2002. Seasonal patterns of biological and physical variables in sediments of Lime Kiln Bay during 2000-2001. Can. Tech. Rep. Fish. Aquat. Sci. 2447: iii + 46 p.

Pendant la période de septembre 2000 à septembre 2001, nous avons procédé à des échantillonnages mensuels (interfaciaux et de profil) de sédiments, à deux stations d'échantillonnage dans la baie Lime Kiln, où l'on pratique la salmoniculture depuis 1981. La station R partait d'une barre de sable, vers la mer, séparant les deux bassins de la baie, et la station E se situait dans le bassin intérieur, du côté de la terre. Les deux stations d'échantillonnage étaient situées à proximité de sites de salmoniculture, mais à plus de 100 mètres de distance des cages afin de ne pas être exposées aux dépôts de déchets alimentaires et de matières fécales des saumons autour des cages. Le présent rapport donne les résultats des prélèvements mensuels des caractéristiques suivantes aux stations R et E : conditions d'oxydo-réduction (rédox), sulfure total, chlorophylle *a*, amino-acides hydrolysables par action enzymatique, température de l'interface des sédiments, imagerie des sédiments de profil et caractéristiques de la communauté macrofaunique.

# INTRODUCTION

For marine coastal ecosystems at temperate latitudes, marked temporal, or seasonal, patterns of productivity and structure are driven by physical-chemical changes. These include, but are not limited to, climate, particularly temperature, as well as the distribution of plant nutrients by hydrodynamic forces and light availability. The purpose of this study was to investigate seasonality within sediments of a cold temperate climate at 45° North as part of the Fisheries and Oceans project - Environmental Studies for Sustainable Aquacuture, ESSA (see Hargrave 2002). There are many implications of seasonality for coastal ecosystem users. One current group of users within coastal areas of the Bay of Fundy is the salmon growers who place Atlantic salmon, *Salmo salar* L., smolts in floating sea-pens for growout in marine conditions, a process which takes 18-24 mo. The environmental effects which result from this activity have been studied in Canada and other parts of the World and are relatively well known (see reviews by Gowen and Bradbury 1987; Findlay and Watling 1997). Based on this understanding, environmental monitoring programs have been devised, e.g. for the Bay of Fundy (see Janowicz and Ross 2001), relying on geochemical measures which require a fall monitoring and spring follow-up, if the farm site shows a high level of organic enrichment. Thus we expected this research to have a practical application: to determine whether seasonality biases geochemical measures and thus influences the interpretation of monitoring results from fall to spring.

Lime Kiln Bay is approximately 2.5 km long by 1 km wide at the mouth (Fig. 1) and opens into Letang Inlet and thence the Bay of Fundy. Lime Kiln Bay is surrounded by salmon farms in Back Bay, Bliss Harbour and inner Letang Harbour (Fig. 1), where a total of 23 farms were present in 2001. Lime Kiln Bay has been continuously used for salmon culture since 1981, with six farms present in 1996. The increasing biomass of salmon carried in the Bay before this time probably contributed (Stewart 1998) to a virus disease epidemic (infectious salmon anemia, ISA) starting in 1996. Ecological models (e.g., Silvert 1994; Cranston 1994) had suggested that the Letang Inlet was exceeding its holding capacity limits for organic wastes, calculated as plant nutrients or ammonium with holding capacity limits estimated between 7000 and 10,000 tonnes of salmon per year for Letang Harbour and vicinity (geographic area defined in Gregory et al. (1993)). The results were refined with hydrodynamic modeling (Trites and Petrie 1995), which also suggested that Lime Kiln Bay was exceeding its holding capacity limits. These results were presented to the industry at a meeting held at the St. Andrews Biological Station in 1996 (unpublished). In 1996, the six farms present within Lime Kiln Bay had a combined allowable production limit of 735,000 fish. Assuming that all were marketed in the same year (unlikely, but the worst case scenario) and using the mean weight (4.36 kg) of ungutted fish at slaughter (Peterson et al. 2001), yields a total of 3205 tonnes per year. After 1998 and a fallowing period imposed by the provincial government following the ISA epidemic, the farm sites have been reduced to four (Fig. 1), presumably with a lower total biomass, and other Bay-wide management initiatives, such as single year-class stocking, implemented. Lime Kiln Bay is now stocked with a fresh batch of smolts every odd year. Thus in even years the total allowable production limit is 540,000 fish x 4.36 kg = 2354 tonnes. In odd years the production will be due only to smolt growth and hence less than this. Similar calculations for the whole of the Letang Harbour and vicinity area in 2001 (as used by Silvert (1994) and Cranston (1994) in their model predictions), based on a mean smolt biomass in the first year of 0.54 kg (Model 3 and initial 120-g smolt size at 17 September, from Peterson et al. (2001)) and market size of 4.36 kg, are shown in Table 1. These calculations suggest that holding capacity limits are still being exceeded.

Table 1. Calculation of annual salmon biomass (tonnes) in bay management areas (BMA's) 8, 9 and 10 based on allowable production limits (APL's as number of fish) for each lease. Lease in BMA 10 with dashed lines in Fig. 1 are excluded. An arbitrary # is used for each lease so that its APL remains confidential

| BMA | # | APL x 1000 | Smolt | Market |
|---|---|---|---|---|
| | 1 | 300 | | |
| | 2 | 250 | | |
| | 3 | 180 | | |
| 8 | 4 | 180 | | |
| | 5 | 130 | | |
| | 6 | 120 | | |
| | 7 | 80 | | |
| | 8 | 80 | 713 | 5755 |
| | 9 | 150 | | |
| | 10 | 120 | | |
| 10 | 11 | 120 | | |
| | 12 | 150 | 292 | 2354 |
| | 13 | 160 | | |
| | 14 | 200 | | |
| | 15 | 135 | | |
| 9 | 16 | 320 | | |
| | 17 | 180 | | |
| | 18 | 200 | | |
| | 19 | 220 | 764 | 6169 |
| | TOTALS | 3,275 | 1,769 | 14,278 |

The purpose of this publication is to record the raw data that we collected in fieldwork in Lime Kiln Bay from the Pandalus III, beginning in September 2000, and terminating in September 2001. We sampled every month (except December 2000) at two fixed locations within Lime Kiln Bay, stations R and E (Fig. 1). The aim of this publication is to facilitate cooperation among scientific collaborators and stakeholders, as well as providing an archived source of detailed information available for reference and publication preparation.

# METHODS

## SAMPLING

### Vessels

The Pandalus III was used to transport SCUBA divers and field crew to the two permanent stations (R, E) in Lime Kiln Bay. Macrofaunal sieving was done on board the Pandalus using pumped seawater. On one occasion when this vessel was not available we used the W.B. Scott (September 2000). We also used a small tender vessel (belonging to Advanced Net Cleaning Services) on some occasions for faster delivery of samples to shore.

### Locations

Two permanent stations were established in Lime Kiln Bay, one seaward of a submerged bar R, and the other landward of it, E (Fig.1). Buoys marked each station with a rope going to concrete block anchors. The R station was based on a lease marking buoy, and the E site by an anchored buoy that we deployed. The sampling area was marked by steel pins and was established close to the concrete anchor. The position of the surface buoys taken from the Pandalus III navigation system was:

R - 45° 03.561 North, 66° 49.499 West
E - 45° 03.895 North, 66° 49.816 West

### Dates

Sampling was undertaken on 12 occasions on the dates shown in Table 2:

Table 2. Sampling dates of the seasonal study.

| Number | Year | Date | Predicted Low Water (AST) |
|---|---|---|---|
| 1 | 2000 | 20/09 | 1215 |
| 2 | | 31/10 | 0810 |
| 3 | | 30/11 | 0825 |
| 4 | 2001 | 04/01 | 1240 |
| 5 | | 28/02 | 0855 |
| 6 | | 30/03 | 0915 |
| 7 | | 30/04 | 1100 |
| 8 | | 16/05 | 1240 |
| 9 | | 27/06 | 1030 |
| 10 | | 26/07 | 1010 |
| 11 | | 22/08 | 0800 |
| 12 | | 19/09 | 0735 |

### SCUBA Team

Advanced Net Cleaning Services of St. George, New Brunswick, provided the diving team, consisting of two divers per trip: Luke Aymar and Dale Tucker. During their absence Joe

Hunt of Fundy Diving Equipment filled in for them. We attempted to begin the dives as near as possible to low water (LW) to limit the depth required for each dive.

**Sampling Gear**

For the initial phases of the work we used both tubular cores and Hargrave wedge cores (Wildish et al. 2003a) deployed by divers. The latter were initially only used for obtaining sediment profile images, but it soon became obvious that we could do all of the sampling with the Hargrave cores by drilling holes in the side walls and covering with duct tape during deployment. Thus for most of the monthly sampling, beginning in November 2000, only the diver-deployed Hargrave corer was used, with five replicate samples taken at each location, R and E.

The Hargrave corer used (diagram in Wildish et al. 2003a) sampled an area of 0.0263 $m^2$ and a completely full core had a volume of 6.2 L. The construction material was of Plexiglas with a hinged top lid and a sliding backplate, which was opened while pushing the corer into the sediment, and then closed to seal the core before transportation to the surface. An aluminum handle allowed the diver to push the wedge core into the sediment and was convenient for carrying two to three corers (filled with seawater at the surface) down to the sampling area. In addition, the Hargrave cores provided sufficient sediment sample to estimate macrofaunal densities. Ten different Hargrave corers were used on each sampling trip.

**Subsampling**

Of the five cores taken at each of the two stations, R and E, the two best were selected for sediment profile imaging (SPI). They were held upright, with the seawater above the core, and carried ashore for interpretation and photography. After this had been completed, they were taken into the building for subsampling. This was achieved by measuring surface sediment redox with a platinum probe and for sulfide drawing up a 5-cc aliquot with a cut-off 5-cc plastic syringe. A small amount of sediment at the surface and at each profile depth was taken on a spatula (<0.2 cc) for chlorophyll a determination. Approximately 5-cc samples were also taken for each of: enzymatically hydrolyzable amino acids (EHAA), sediment particle sizing, plus organic matter analysis. These two samples were placed in labeled plastic bags and stored frozen.

Subsampling on the three Hargrave cores/station left aboard the Pandalus was only for surface sediments scraped up in a 30-cc plastic container (analyzed in the shore laboratory for redox, sulfide, chlorophyll a, EHAA, sediment particle sizing and carbon). Once these samples had been taken, the sediment in the Hargrave cores was washed onto a series of sieves to separate the macrofauna.

Sediment profiling was done on the two cores/station that were photographed, by inserting the platinum redox probe into the drill hole after removing the duct tape, followed by removal of sediment in a cut-off syringe, for sulfide, chlorophyll a, EHAA, and organic matter. During work-up of these samples, which took 4-6 h, the sediment heated up in the room. Because redox is temperature sensitive, we measured sediment temperature at the time of subsampling.

## VARIABLES MEASURED

The following 10 variables were measured: redox, total sulfide, chlorophyll a, phaeo-pigments, EHAA, temperature, organic matter, sediment particle characterization, sediment profile imaging and macrofaunal community characteristics. In addition, we used wind speed and direction data from the Point Lepreau monitoring station (Environment Canada).

Because it is not given elsewhere, we present a detailed description of our of methods for SPI and plant pigment analysis.

### Redox

The method followed was that in Wildish et al. (1999), except that the platinum electrode was filled with 4.0 M KCl (and not 0.2 M as erroneously stated on p. 5 of Wildish et al. 1999). The mV readings were read on an Accumet ion meter and corrected to the normal hydrogen electrode (NHE) at the measured sample temperature at the time of analysis:

$$E_{NHE} = E_O + C ,$$

where $E_O$ = mV of unknown and C = mV of NHE electrode at sample temperature (see Table 1 in Wildish et al. 1999).

### Total Sulfide

Total sulfides in sediments were measured by the electrochemical method of Berner (1963) with the same Accumet ion meter and Orion silver/sulfide half cell and reference electrodes according to the detailed methods given in Wildish et al. (1999). The L-ascorbic acid was preweighed and added to the sulfide anti-oxidant buffer solution (SAOB) just before use. Standard solutions of sodium sulfide stock and SAOB, and unknown sediment slurries and SAOB were added together in the same 1: 1 volumetric ratios. The results are given as micromoles of sodium sulfide, μM.

### Chlorophyll a (Chl a) and Phaeo-pigments

The method is based on that in Strickland and Parsons (1968) adapted for sediments.

Field equipment list

15-mL graduated tubes with screw caps
Each tube is filled with 10 mL of 90% acetone
Spatula for removing sediment
Vortex mixer
Magnesium carbonate slurry (1% solution in distilled water)
Pasteur pipets and rubber bulbs for dispensation of above
Ice chest half full of crushed ice

Initial field analysis

A small amount of sediment was added to a labeled tube containing 90% acetone (variable amounts according to how much green colour it produces); one to two drops of magnesium carbonate slurry were added; the tube was vortically mixed for 1 min; the tubes were then placed in the ice chest in the dark.

Laboratory analysis after ~12 h refrigeration

On return to the lab the graduated tubes were refrigerated in the dark overnight. The next day tubes were removed from the refrigerator and allowed to equilibrate to lab temperature. Each tube was centrifuged at 3000 g for 10 min and 5 mL of the supernate removed. Fluorescence was recorded in a Model 10-AU-005 Turner Designs fluorometer (Sunnyvale, CA, U.S.A.) fitted with a light-tight cuvet holder. The fluorometer was fitted with a blue excitation filter and a red filter, selected for chlorophyll a determination.

The supernate sample was pipetted into pyrex 1-cm cuvets and the fluorescence determined against a blank of 90% acetone. Standard samples of chlorophyll a (from Sigma) in 90% acetone were also run ($R_B$) to determine a calibration curve. Following the first reading 1-2 drops of 1N HCl was added to the cuvet which was mixed by inverting it twice, and the fluorescence value read again ($R_A$). The acid factor, r, was calculated for standard samples: $r = R_B/R_A$. The average r = 1.94, and the factor r/r-1 = 2.07. The calibration was gravimetrically based: the addition of 1 mg of pure chlorophyll a to 1 L of 90% acetone. The calculations for estimating chlorophyll a and phaeo-pigments were as in Strickland and Parsons (1968). The conversion factor, F = 0.03, was derived by dividing the chlorophyll a concentration by $R_B$.

To the remaining sediment, after discarding any supernate, 10 mL of deionized water was added, followed by vortex mixing. The tubes were left overnight to leach out the sea salts. The supernate was then discarded and the sediment pellet quantitatively transferred with a wash bottle to a pre-weighed and numbered aluminum dish for dry weight determination.

The dishes were placed in a convection oven for drying for 24 h at 80°C.

The sediment sample weight was the difference between the last and first weighings and results expressed as µg chlorophyll a or phaeo-pigment/g dry sediment. Total pigments were also calculated by adding the two values as in Hargrave and Phillips (1981).

Chlorophyll a:

Dilution factor (µg/mL) ÷ g dry sediment $0.03\ [(r/r - 1)\ (R_B - R_A)]$

Phaeophytin:

Dilution factor (µg/mL) ÷ g dry sediment $0.03\ [(r \times R_A) - R_B](r/r - 1)$

**Enzymatically Hydrolyzable Amino Acids (EHAA)**

Samples in plastic bags were stored in the freezer. They were delivered to the laboratory of Dr. Larry Mayer in a cooler chest, where they were analyzed for bioavailable amino acids by the method of Mayer et al. (1995). The sediments were freeze dried before incubation with Proteinase K (from Sigma) and microbial inhibitors and the products, amino acids, visualized

with a fluorochrome (orthophthaldialdehyde reagent) and measured spectrofluometrically. The results are expressed as µg EHAA/g dry sediment.

**Temperature**

Continuous measurements of temperature were made with StowAway Tidbit units (available from Onset Computer Corp., 470 MacArthur Blvd., Bourne, MA 02532, U.S.A.). Each unit was set to record temperatures every 30 min and placed at the sediment-water interface secured to the anchor block. The results, as daily means, were downloaded to a laptop computer and analyzed with a Microsoft Excel pivot table.

**Sediment Particle Analysis**

Frozen samples in plastic bags were transported on ice to the Bedford Institute of Oceanography.

**Organic matter**

Some of the above samples were analyzed under contract for total carbon by weight loss on ignition at different temperatures to give labile (at 280°C) and total (at 520°C).

**Wind direction and speed**

An MS Excel data file for wind direction, speed, air temperature and % relative humidity was obtained from Environment Canada. Each of the four variables was averaged hourly in the period 1 September 2000 to 30 September 2001. The data for the 24 h prior to each sampling is presented in Appendix 3.

**Sediment Profile Imaging (SPI)**

Equipment list for fieldwork:

Hargrave core samplers (10)
Wooden stands for the samplers, painted matte black
Kodak DC 290 camera
Camera tripod
Felt for cleaning the Plexiglas surfaces of the sampler
Siphon apparatus for removing seawater above the sediment

Preparation for fieldwork: Camera batteries were recharged overnight; a blank picture card was installed in the camera; the camera was pre-set to use auto flash and highest picture resolution.

**Fieldwork**

After the SCUBA divers had taken the samples, they were kept upright by placing them on wooden stands. The Plexiglas surface through which the photographs were taken was cleaned with a seawater hose so that sediment smearing did not occur.

Best results were obtained if the photography was done on land, where diffused lighting and sun position could be better controlled.

The camera was set up on its tripod about 1-2 m from the samplers, preferably outside in natural lighting. Care was taken to see that the plane of the camera was nearly at right angles to

the sediment profile. After adjusting the focus with the aid of the picture shown on the back of the camera, two exposures were made for each sample taken. All parts of the sediment profile were kept within the picture frame.

Downloading from the Kodak DC 290 to a PC: Remove the picture card from the camera and insert into the computer-compatible interface. Click and drag each JPEG file to a PC storage file. Check that each JPEG image is present on the PC file. Retain the images on the Picture Card as long as possible as backup in case of file crashes.

Analysis of digital profile images: The variables observed in the computerized images are as in Nilsson and Rosenberg (2000).

*System requirements*

PC with frame grabber board
Image analysis software (e.g. Optimas 6.2, Image Pro Plus, SigmaScan)
PC Log On
Put disks with the SPI in the PC and open it.
Define the redox potential discontinuity (RPD) layer with the Toolbar greenline
Calculate the total area of the RPD layer
Divide the area by the sampled width (= 17.5 cm wide in our corers) to give the mean RPD depth
If necessary the different areas can be enhanced by changing the contrast settings
Repeat this procedure to obtain the total mean core depth
Enter the SPI number, the mean core and RPD depths in cm, on the assessment sheet provided
Complete the assessment sheet by answering the yes/no questions shown from each SPI
Calculate the Benthic Habitat Quality index (BHQ) of Table 3, Nilsson and Rosenberg (2000) which can range from 0 to 15
Correspondence between the BHQ and the organic enrichment index (OE) from Pearson and Rosenberg (1978) is as in Table 3:

Table 3. Equivalent groups for Benthic Habitat Quality and the Organic Enrichment Index.

| Description | BHQ | OE |
|---|---|---|
| Normal | >10 | III |
| Oxic | 5-10 | II |
| Hypoxic | 2-4 | I |
| Anoxic | <2 | 0 |

## Macrofauna

The three Hargrave core samples taken for macrofaunal analysis were lumped during sieving by washing with seawater through two sieves, the lower one having a mesh size of 1 $mm^2$. The sieve contents were carefully collected and placed in small plastic pails with a little seawater and full strength formalin (40%) in sufficient quantity to make a 5-10% solution.

Plastic tops were then hammered in place to make an airtight seal. The labeled pails were stored until analysis at the Atlantic Reference Centre (ARC), Huntsman Marine Science Centre. Standard sorting and taxonomic procedures developed at the ARC were employed (Lim and Gratto 1992; Pohle and Frost 1997). Species were identified to the lowest possible taxon, individuals counted and a total biomass (of alcohol preserved specimens) determined.

## RESULTS

The results are summarized in Appendices 1-5 and a preliminary appraisal offered here. Primary publications expected to result from this work include Wildish et al. (2003b) regarding seasonality in sediment interfacial redoxes and a method for correcting for this in temperate climates of either southern or northern hemispheres. Another, concerning the seasonality of all variables measured, is in preparation.

### SEDIMENT INTERFACE

Interfacial sediments are considered here to be within the top 2 cm of the profile from the sediment-water interface downwards. The sub-sampling tools used (probe tips, cut-off syringes, spatula) did not allow the mm - scale sampling reported by some investigators.

The data available are shown in Appendix 1, including phaeo-pigments. The organic matter measurements by ashing and particle sizes were not yet available. EHAA samples were taken only in the months of March (winter) and July (summer). The early attempts to deploy Tidbit units for temperature measurement resulted in losses of the units due to chafing with anchor chains and ropes, and only at the third attempt, were we able to place a unit which stayed in place, and we could find, after 7 mo (Appendix 2).

Temporal patterns of redox, sulfide, chlorophyll a and temperature are shown in Fig. 2-5. Redox shows a generally sine wave pattern with season (Fig. 2), with an anomalously low value in August. The August anomaly, which coincides with maximum temperatures (Fig. 5), was not correlated with high sulfide levels (Fig. 3). We propose (Wildish et al. 2003b) that this is because in aerobic sediments, redox values follow the general seasonal pattern in seawater; in the biologically active period there is a decline in oxygen, which is markedly accelerated when phytoplankton become limited late in the summer, when microbial aerobes are still actively respiring. Thus the negative redoxes of August are linked to the large deficit present then between oxygen production and utilization in favor of the latter. The chlorophyll a seasonality (Fig. 4) shows a summer high, which is reduced by August. This measure includes interfacial diatoms as well as phytoplankton which sediments from the water column.

### SEDIMENT PROFILES

Shown in Fig. 6 are examples of profiles from stations R and E for March 2001. For the former the maximum sampling depth was 12 cm due to penetration resistance in coarser sediments. At E, the finer sediments allowed greater penetration, to 20 cm. The redox and sulfide values are consistent with the visual data obtained, with SPI regarding the redox discontinuity depth, which for R6 was 4.8 cm and for E1 was 5.6 cm. The high chlorophyll a at E1 in the surface sediment suggests that an early season diatom bloom was in progress.

## WHOLE CORE SAMPLES

The SPI data are presented as benthic habitat quality indices (BHQ), as RPD depths and the organic enrichment (OE) index equivalent to the BHQ (Appendix 4). There is slight evidence of seasonal changes of RPD, with maximum depths in the month before the lowest measure of redox was recorded. There is little evidence of seasonal change in BHQ and none in OE.

Macrofaunal data are given as species times density matrices in Appendix 5. Principal results from these data are that station R has a more diverse macrofaunal community, with 93 species versus E with 68 species from 11 monthly samplings. Since each monthly sampling was based on three lumped cores, the area sampled is 0.0263 x 3 = 0.0788 $m^2$. The density data of Appendix 5 can be converted to number/$m^2$ by multiplying by 12.67.

There was no evidence of seasonality in the data as far as species diversity or total biomass was concerned as shown in Table 4, extracted from Appendix 5:

Table 4. Monthly macrofaunal species number (S) and biomass (B) in g/$m^2$. Note that biomass is higher at R than E for all months except in May.

| Month | E | | R | |
|---|---|---|---|---|
| | S | B | S | B |
| October | 27 | 19.82 | 41 | 195.24 |
| November | 23 | 7.41 | 42 | 60.45 |
| January | 21 | 4.38 | 51 | 54.71 |
| February | 22 | 5.90 | 48 | 41.60 |
| March | 20 | 20.50 | 45 | 148.24 |
| April | 21 | 2.55 | 50 | 126.89 |
| May | 25 | 35.48 | 30 | 22.82 |
| June | 36 | 16.76 | 44 | 90.65 |
| July | 21 | 21.68 | 34 | 50.55 |
| August | 31 | 8.95 | 48 | 33.79 |
| September | 26 | 9.96 | 43 | 31.65 |

## DISCUSSION

Most of the data in Appendices 1-5 awaits further detailed analysis. Only sediment interfacial redoxes have been examined closely (Wildish et. al. 2003b) and shows that in sedimentary profiles with an aerobic upper layer, redoxes have a seasonal, sine wave pattern. The pattern decreases with increasing temperatures (when biological activity is high) and increases with decreasing temperatures (when biological activity is low). In highly organically enriched conditions where anaerobiosis reaches the sediment-water interface, interfacial redoxes

are an inverse function of total sulfide as found previously (Hargrave et al. 1997; Wildish et al. 1999).

The demonstration here, that redox values in aerobic sediments are seasonal, has implications for environmental monitoring, notably in using geochemical measures to designate organic enrichment macrofaunal community stages. This is discussed in Wildish et al. (2003b) where the protocol proposed is as follows. In surficial sediments where an established farm is present, the redox is considered to be inversely related to sulfide and no seasonal correction is needed. Where farms are new and sulfide levels may not have built up in surficial sediments, the redox may be seasonal and a correction may be required. If necessary, we recommend correcting redox seasonally, with the aid of the simple models given in Wildish et al. (2003b), to correspond to the timing of original sampling.

Although there appears to be no evidence for seasonality in total sulfides in the present data (Fig. 3), the possibility that enriched sediments, where sulfides exceed 1300 μM, may show that a seasonal signal exists and needs to be investigated. In Chesapeake Bay sediments, Marvin-DiPasquale and Capone (1998) found that there was a seasonal periodicity of sulfate reduction. This was controlled by temperature, carbon and sulfate limitation, and the presence/absence of macrofauna or dissolved oxygen. Since our ion analytic method measures total sulfides, inclusive of iron pyrites which are stable in most sediments, the seasonal cycling of sulfate reduction may be masked by the presence of a large reservoir of metallic sulfides.

There are indications that sediments in Lime Kiln Bay are eutrophicated, particularly by the seasonal presence of high levels of chlorophyll a in the surface layers. These pigments originate from interfacial diatoms as well as phytoplankton from the water column, which may settle onto sediments during senescence. The generally high levels of total sulfide and low redoxes (which also varies seasonally) are indicators that microbial activity is high, consistent with a high level of sedimentary metabolism, and hence eutrophication. This is consistent with the plant nutrient predictive model outputs discussed in the "Introduction."

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## REFERENCES

Berner, R.A. 1963. Electrode studies of hydrogen sulphide in marine sediments. Geochim. Cosmochim. Acta 27: 563-575.

Cranston, R. 1994. Dissolved ammonium and sulfate gradients in surficial sediment pore water as a measure of organic carbon burial rate. *In* Modelling benthic impacts of organic enrichment from marine aquaculture. *Edited by* B.T. Hargrave. Can. Tech. Rep. Fish. Aquat. Sci. 1949: p. 93.

Findlay, R.H., Watling, L. 1997. Prediction of benthic impact for salmon net-pens based on the balance of benthic oxygen supply and demand. Mar. Ecol. Prog. Ser. 155: 147-157.

Gowen, R.J., and Bradbury, N.B. 1987. The ecological impact of salmonid farming in coastal waters: a review. Oceanogr. Mar. Biol. Annu. Rev. 25: 563-575.

Gregory, D., Petrie, B. Jordan, F., and Langille, P. 1993. Oceanographic, geographic, and hydrological parameters of Scotia-Fundy and southern Gulf of St.Lawrence inlets. Can. Tech. Rep. Hydrogr. Ocean Sci. 143: 248 p.

Hargrave, B.T.H., and Phillips, G.A. 1981. Annual in situ carbon dioxide and oxygen flux across a subtidal marine sediment. Estuar. Coast. Shelf. Sci. 12: 725-737.

Hargrave, B.T., Phillips, G.A., Doucette, L.I., White, M.J., Milligan, D.J., Wildish, D.J. and Cranston, R.E. 1997. Assessing benthic impacts of organic enrichment from marine aquaculture. Water Air Soil Pollut. 99: 641-650.

Hargrave, B.T. 2002. Environmental studies for sustainable aquaculture (ESSA): 2002 workshop report. Can. Tech. Rep. Fish. Aquat. Sci. 2411: 112 p.

Janowicz, M., and Ross, J. 2001. Monitoring for benthic impacts in the southwest New Brunswick salmon aquaculture industry. ICES. J. Mar. Sci. 58: 453-459.

Lim, S.S.L., and Gratto, G.W. 1992. The effects of organic enrichment from Atlantic salmon aquaculture sites on the benthic macrofaunal communities in the lower Bay of Fundy. Final report to the New Brunswick Department of Fisheries and Aquaculture, 168 p.

Marvin-DiPasquale, M.C., and Capone, D.G. 1998. Benthic sulfate reduction along the Chesapeake Bay central channel. I. Spatial trends and controls. Mar. Ecol. Prog. Ser. 168: 213-228.

Mayer, L.M., Schick, L.L. Sawyer, T., and Plante, C.J. 1995. Bioavailable amino acids in sediments: a biomimetic, kinetics-based approach. Limnol. Oceanogr. 40: 511-520.

Nilsson, H. C., and Rosenberg, R. 2000. Succession in marine benthic habitats and fauna in response to oxygen deficiency: analysed by sediment-profile imaging and by grab samples. Mar. Ecol. Prog. Ser. 197: 139-149.

Pearson, T.H., and Rosenberg, R 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanogr. Mar. Biol. Annu. Rev. 16: 229-311.

Peterson, R.H., Page, F., Steeves, G.D., Wildish, D.J., Harmon, P., and Losier, R. 2001. A survey of 20 Atlantic salmon farms in the Bay of Fundy: influence of environmental and husbandry variables on performance. Can. Tech. Rep. Fish. Aquat. Sci. 2337: 117 p.

Pohle, G., and Frost, F. 1997. Establishment of standard benthic monitoring sites to assess long-term ecological modification and provide predictive sequence of benthic community succession in the inner Bay of Fundy, New Brunswick. Final report to the New Brunswick Department of Fisheries and Aquaculture, 119 p.

Stewart, J.E. 1998. Sharing the waters: an evaluation of site fallowing, year class separation and distances between sites for fish health purposes on Atlantic salmon farms. Can. Tech. Rep. Fish. Aquat. Sci. 2218: 63 p.

Silvert, W. 1994. Modelling benthic deposition and impacts of organic matter loading. *In* Modelling benthic impacts of organic enrichment from marine aquaculture. Edited by B.T. Hargrave. Can. Tech. Rep. Fish. Aquat. Sci. 1949: 1-18.

Strickland, J.D.H., and Parsons, T.R. 1968. A practical handbook of seawater analysis. Fish. Res. Board Can. Bull. 167: 311 p.

Trites, R.W., and Petrie, L. 1995. Physical oceanographic features of Letang Inlet including evaluation and results from a numerical model. Can. Tech. Rep. Hydrogr. Ocean Sci. 163: 55 p.

Wildish, D.J., Akagi, H.M., Hamilton, N., and Hargrave, B.T. 1999. A recommended method for monitoring sediments to detect organic enrichment from mariculture in the Bay of Fundy. Can. Tech. Rep. Fish. Aquat. Sci. 2286: 31 p.

Wildish, D.J., Hargrave, B.T., MacLeod, C., and Crawford, C.M. 2003a. Detection of organic enrichment near finfish net-pens by sediment profile imaging at SCUBA-accessible depths. Submitted to J. Exp. Mar. Biol. Ecol.

Wildish, D.J., Barmuta, L., Crawford, C.M., MacLeod, C., and Butler, C.V.E. 2003b. Seasonality of redox measurements in interfacial marine sediments near salmon farms. Submitted to: Mar. Freshwat. Res.

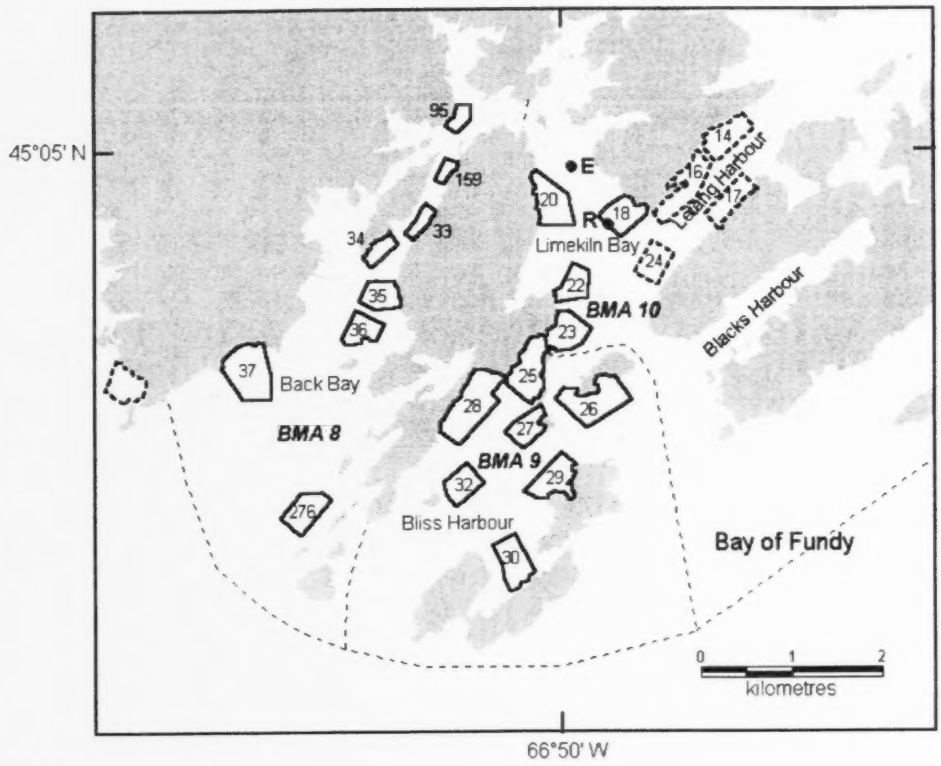


Fig. 1. Map of Letang Inlet showing Lime Kiln Bay and positions of stations R and E. Numbers refer to salmon farm leases in 2002. Sites 14, 16, 17 and 24 were not included in the Letang Harbour and vicinity model quoted. BMA = Bay Management Area.

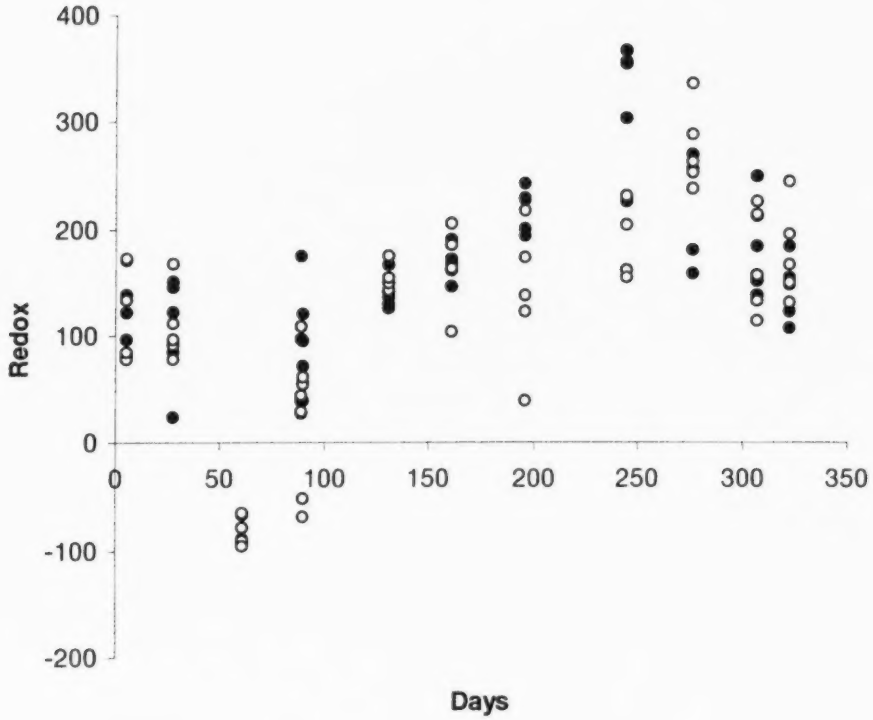


Fig. 2. Seasonality of redox in interfacial sediments at stations R (filled circles) and E (open circles), Lime Kiln Bay. Days are from the summer solstice (22 June in the northern hemisphere).

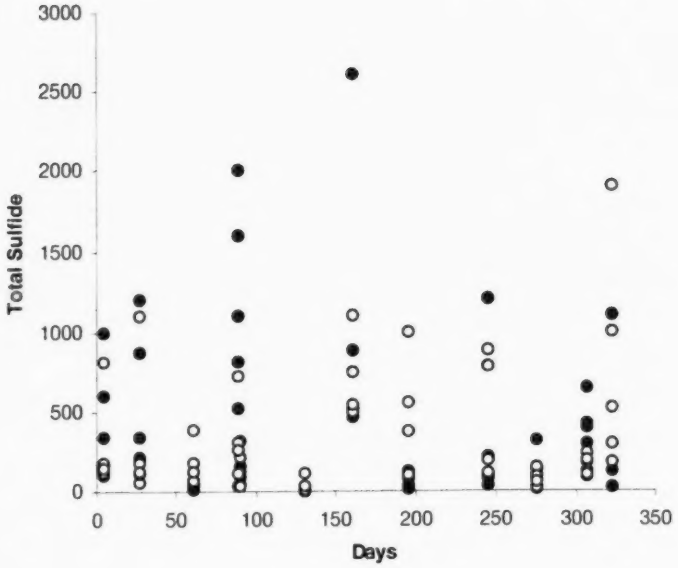


Fig. 3. Seasonality of total sulfides in interfacial sediments at station R and E, Lime Kiln Bay. Symbols as in Fig. 2.

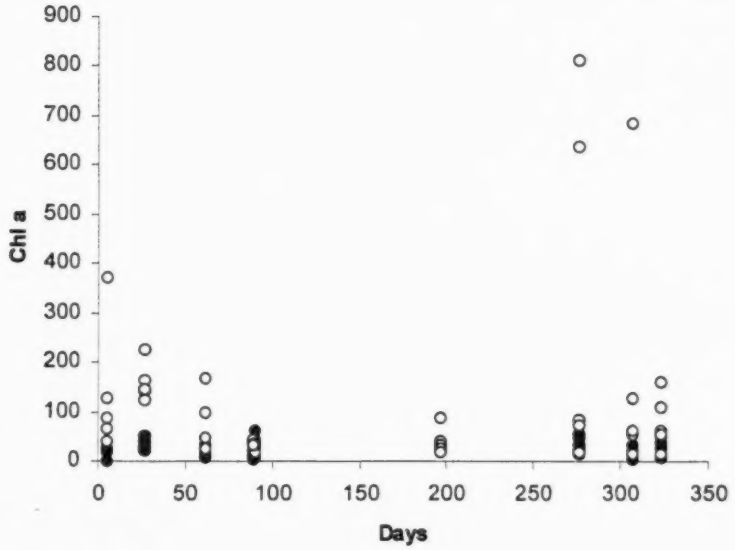


Fig. 4. Seasonality of chlorophyll a in interfacial sediments at station E and R, Lime Kiln Bay. Symbols as in Fig.2.

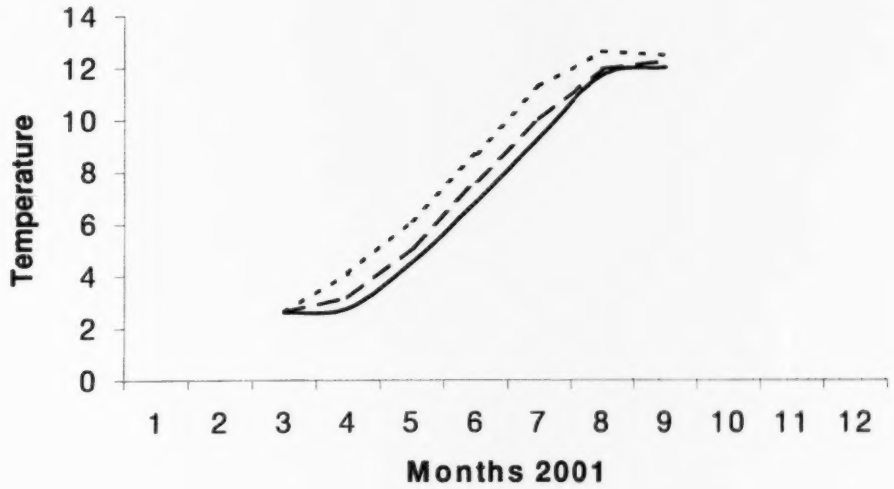


Fig. 5. Sediment interfacial temperatures at station E, Lime Kiln Bay. Upper line is the maximum and lower line the minimum daily mean temperature. The middle line is the monthly average of all daily mean temperatures.

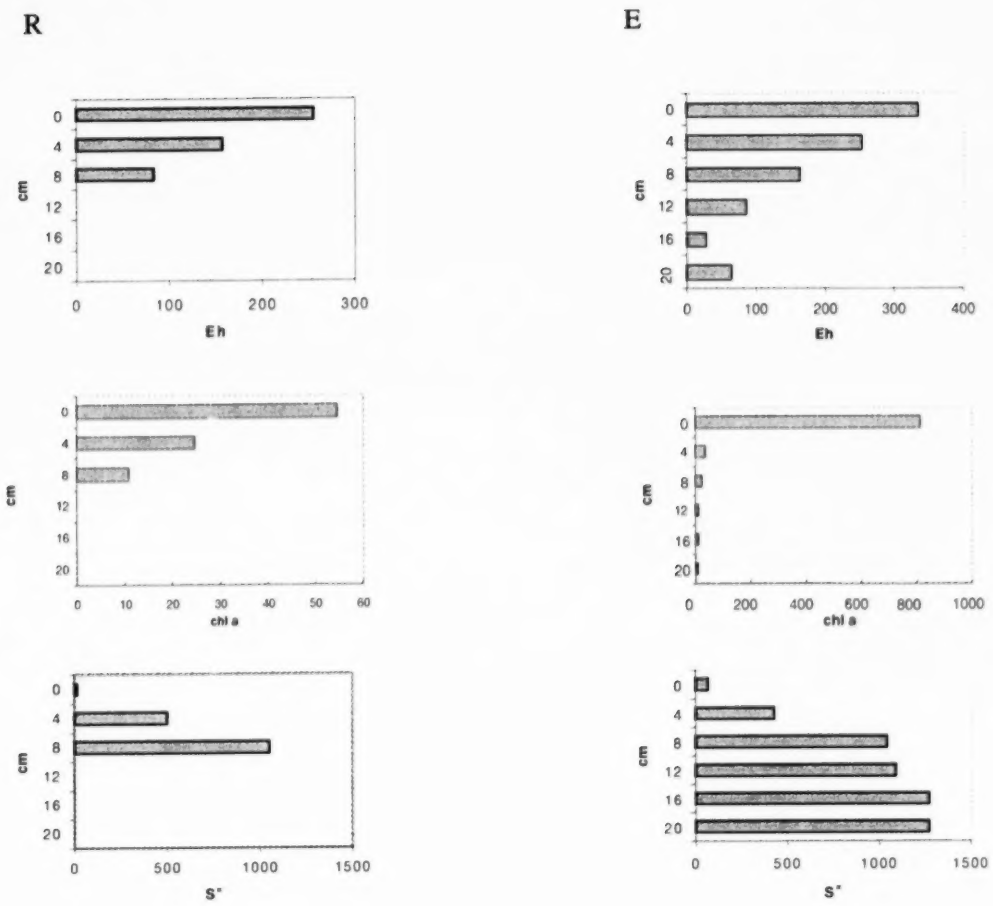


Fig. 6. Sediment profiling at stations R and E, Lime Kiln Bay on 30 March 2001 for chlorophyll a (Chl a), redox (Eh) and total sulfide ($S^{=}$) as μM. Profile depths are in centimeters (cm).

Appendix 1. Monthly sediment interface and profiling results at stations R and E, Lime Kiln Bay for the period 20 September 2000 to 19 September 2001. The numbers after R or E indicate the sequential core used and the numbers after the dash show the sampling depth in cm ( 0 = 0-2 cm)

20-Sept-00

| No. | Chl a µg/g | Phaeo., µg/g | Total | $Eh_{NHE}$, mV | $S^{=}$ µM |
|---|---|---|---|---|---|
| Surface | | | | | |
| R1-0 | 7.79 | 63.21 | 70.99 | 72 | 91 |
| R2-0 | 7.98 | 52.98 | 60.97 | 40 | 120 |
| R3-0 | 60.42 | 238.00 | 298.42 | 120 | 220 |
| R4-0 | 44.88 | 309.12 | 353.99 | 95 | 160 |
| R5-0 | 15.72 | 97.67 | 113.39 | 39 | 320 |
| E1-0 | 16.30 | 167.13 | 183.43 | 57 | 110 |
| E2-0 | 20.95 | 87.03 | 107.97 | -51 | 220 |
| E3-0 | 19.50 | 78.13 | 97.63 | 54 | 35 |
| E4-0 | 32.52 | 153.79 | 186.31 | 61 | 40 |
| E5-0 | 36.98 | 165.36 | 202.34 | -69 | 31 |
| Profile | | | | | |
| R1-0 | 17.08 | 169.41 | 186.49 | 58 | 69 |
| R1-4 | 9.13 | 90.62 | 99.76 | 78 | 320 |
| R1-8 | 0.74 | 8.63 | 9.37 | -63 | 2300 |
| R1-12 | 2.36 | 22.91 | 25.27 | -60 | 1700 |
| R1-16 | 0.70 | 8.76 | 9.47 | -156 | 1100 |
| R2-0 | 12.24 | 306.00 | 318.23 | 28 | 180 |
| R2-4 | 19.85 | 97.43 | 117.28 | 35 | 270 |
| R2-8 | 3.55 | 45.33 | 48.87 | -20 | 340 |
| R2-12 | 1.79 | 28.61 | 30.39 | -115 | 2200 |
| R2-16 | 0.55 | 9.61 | 10.16 | -109 | 3700 |
| R2-20 | 0.47 | 8.07 | 8.54 | -174 | 5800 |
| E1-0 | 43.48 | 148.78 | 192.26 | 97 | 120 |
| E1-4 | 14.20 | 85.27 | 99.47 | 7 | 510 |
| E1-8 | 7.00 | 42.95 | 49.95 | -3 | 880 |
| E1-12 | 1.96 | 33.30 | 35.27 | -44 | 890 |
| E1-16 | 2.81 | 53.91 | 56.72 | -46 | 360 |
| E1-20 | | | | -70 | 700 |
| E1-24 | | | | -62 | 340 |
| E1-28 | | | | -82 | 1600 |
| E2-0 | 33.06 | 109.89 | 142.94 | 21 | 410 |
| E2-4 | 36.47 | 130.10 | 166.57 | 51 | 170 |
| E2-8 | 13.96 | 98.41 | 112.37 | -39 | 700 |
| E2-12 | 13.59 | 66.87 | 80.46 | -31 | 730 |
| E2-16 | 1.37 | 65.37 | 66.74 | -90 | 1800 |
| E2-20 | 6.25 | 43.19 | 49.45 | -100 | 3100 |
| E2-24 | 3.92 | 29.26 | 33.18 | 33 | 190 |

31–Oct-00

| No. | Chl a, µg /g | $Eh_{NHE}$, mV | $S^{=}$, µM |
|---|---|---|---|
| Surface | | | |
| R1-0 | | 126 | 1.2 |
| R2-0 | | 135 | 0.73 |
| R3-0 | | 140 | 2.7 |
| R4-0 | | 129 | 13 |
| R5-0 | | 166 | 13 |
| E1-0 | | 174 | 11 |
| E2-0 | | 150 | 30 |
| E3-0 | | 142 | 110 |
| E4-0 | | 149 | 12 |
| E5-0 | | 154 | 30 |
| | | | |
| Profiles | | | |
| R4-4 | | 111 | 120 |
| R5-4 | | 115 | 110 |
| R5-8 | | 85 | 110 |
| E1-4 | | 71 | 110 |
| E1-8 | | 56 | 240 |
| E1-12 | | -30 | 260 |
| E3-4 | | -30 | 210 |
| E3-8 | | -67 | 260 |
| E3-12 | | -14 | 120 |
| E3-16 | | -3 | 32 |

30-Nov-00

| No. | Chl a, µg/g | $Eh_{NHE}$, mV | $S^{=}$, µM |
|---|---|---|---|
| Surface | | | |
| R1-0 | | 146 | 460 |
| R3-0 | | 167 | 1100 |
| R4-0 | | 189 | 880 |
| R5-0 | | 170 | 520 |
| R6-0 | | 161 | 2600 |
| E1-0 | | 204 | 1100 |
| E2-0 | | 184 | 750 |
| E4-0 | | 162 | 500 |
| E6-0 | | 103 | 1100 |
| E7-0 | | 184 | 540 |
| | | | |
| Profiles | | | |
| R3-4 | | 83 | 2000 |
| R3-8 | | -34 | 4100 |
| R5-4 | | 131 | 3100 |
| R5-8 | | 57 | 5500 |
| E1-4 | | 214 | 5300 |
| E1-8 | | 19 | 6100 |
| E1-12 | | -65 | 7500 |
| E1-16 | | -47 | 6900 |
| E2-4 | | 148 | 3800 |
| E2-8 | | -25 | 5200 |
| E2-12 | | 21 | 3300 |
| E2-16 | | 14 | 3600 |

4-Jan-01

| No. | Chl a, µg/g | Phaeo., µg/g | Total | $Eh_{NHE}$, mV | $S^{=}$, µM |
|---|---|---|---|---|---|
| Surface | | | | | |
| R1-0 | 39.57 | 147.22 | 186.79 | 226 | 120 |
| R2-0 | 22.29 | 104.60 | 126.88 | 242 | 12 |
| R3-0 | 20.59 | 84.75 | 105.34 | 193 | 76 |
| R4-0 | 29.96 | 119.14 | 149.10 | 228 | 34 |
| R5-0 | 19.18 | 69.06 | 88.24 | 199 | 16 |
| E2-0 | 40.70 | 176.57 | 217.27 | 217 | 100 |
| E4-0 | 31.26 | 86.89 | 118.15 | 40 | 550 |
| E5-0 | 25.78 | 102.17 | 127.94 | 122 | 1000 |
| E6-0 | 18.69 | 67.65 | 86.34 | 137 | 370 |
| E7-0 | 87.88 | 350.75 | 438.64 | 172 | 100 |
| Profiles | | | | | |
| R1-4 | 32.31 | 141.13 | 173.44 | 100 | 1100 |
| R1-8 | | | | 6 | 1100 |
| R3-4 | 5.12 | 23.74 | 28.85 | 73 | 940 |
| R3-8 | 5.11 | 23.72 | 28.84 | 27 | 1000 |
| E5-4 | 19.80 | 77.65 | 97.45 | 123 | 1200 |
| E5-8 | | | | 107 | 1500 |
| E5-12 | 2.02 | 51.62 | 53.65 | 34 | 2100 |
| E5-16 | 14.39 | 78.50 | 92.89 | -6 | 2300 |
| E5-20 | 5.14 | 37.71 | 42.85 | 5 | 1200 |
| E6-4 | 23.55 | 53.97 | 77.52 | 141 | 1000 |
| E6-8 | 18.92 | 58.41 | 77.33 | 59 | 1200 |
| E6-12 | 9.02 | 36.26 | 45.28 | -16 | 1300 |
| E6-16 | 6.99 | 37.31 | 44.29 | 17 | 800 |
| E6-20 | 9.90 | 75.90 | 85.79 | 182 | 420 |

28-Feb-01

| No. | Chl a, µg/g | $Eh_{NHE}$, mV | $S^{=}$, µM |
|---|---|---|---|
| Surface | | | |
| R1-0 | | 334 | 100 |
| R2-0 | | 344 | 210 |
| R3-0 | | 204 | 74 |
| R4-0 | | 332 | 1200 |
| R5-0 | | 282 | 37 |
| E1-0 | | 141 | 110 |
| E2-0 | | 182 | 190 |
| E3-0 | | 134 | 7800 |
| E4-0 | | 209 | 880 |
| E5-0* | | | |
| Profiles | | | |
| R1-4 | | 385 | 21 |
| R1-8 | | 228 | 320 |
| R1-12 | | 139 | 1100 |
| R5-4 | | 213 | 160 |
| R5-8 | | -38 | 1600 |
| E4-4 | | 139 | 5400 |
| E4-8 | | 105 | 1100 |
| E4-12 | | -31 | 2700 |
| E4-16 | | -20 | 1400 |

* Absent

30-March-01

| No. | Chl a, µg/g | Phaeo., µg/g | Total | $Eh_{NHE}$, mV | $S^{=}$, µM | EHAA mg(AA)/g |
|---|---|---|---|---|---|---|
| Surface | | | | | | |
| R2-0 | 20.98 | 87.57 | 108.55 | 268 | 96.8 | 0.78 |
| R3-0 | 16.33 | 51.52 | 67.85 | 157 | 316 | 0.68 |
| R5-0 | 48.92 | 83.03 | 131.95 | 184 | 59.6 | 2.13 |
| R6-0 | 54.51 | 114.99 | 169.50 | 255 | 14.9 | 1.05 |
| R7-0 | 33.99 | 67.30 | 101.29 | 269 | 135 | 0.83 |
| E1-0 | 813.96 | 75.74 | 889.70 | 339 | 67.9 | 1.95 |
| E2-0 | 19.96 | 49.75 | 69.70 | 287 | 23.4 | 4.50 |
| E4-0 | 637.00 | 119.10 | 756.10 | 221 | 177 | 2.12 |
| E5-0 | 84.17 | 127.32 | 211.48 | 236 | 95.3 | 2.38 |
| E6-0 | 73.69 | 118.94 | 192.63 | 252 | 59.4 | 1.05 |
| Profile | | | | | | |
| R5-8 | 32.29 | 75.31 | 107.60 | 113 | 561 | 1.01 |
| R6-4 | 24.72 | 64.67 | 89.39 | 172 | 500 | 1.03 |
| R6-8 | 10.83 | 39.60 | 50.44 | 98 | 1050 | 0.78 |
| E1-4 | 35.75 | 138.18 | 173.93 | 269 | 428 | 1.38 |
| E1-8 | 22.02 | 69.33 | 91.35 | 179 | 1040 | 1.24 |
| E1-12 | 9.62 | 43.96 | 53.58 | 101 | 1090 | 1.05 |
| E1-16 | 9.64 | 44.14 | 53.78 | 43 | 1270 | 1.00 |
| E1-20 | 7.90 | 36.73 | 44.63 | 81 | 1270 | 0.78 |
| E4-4 | 148.69 | 145.84 | 294.53 | 165 | 485 | 1.24 |
| E4-8 | 47.91 | 168.72 | 216.63 | 149 | 771 | 1.30 |
| E4-12 | 34.53 | 98.54 | 133.07 | 114 | 1010 | 0.89 |
| E4-16 | 12.91 | 56.83 | 69.74 | 170 | 740 | 0.57 |
| E4-20 | 8.53 | 39.95 | 48.47 | 102 | 1060 | 0.51 |

30-April-01

| No. | Chl a, µg/g | Phaeo., µg/g | Total | $Eh_{NHE}$, mV | $S^{=}$, µM |
|---|---|---|---|---|---|
| Surface | | | | | |
| R1-0 | 10.39 | 41.96 | 52.35 | 137 | 400 |
| R2-0 | 23.20 | 75.03 | 98.24 | 248 | 420 |
| R3-0 | 4.06 | 27.25 | 31.31 | 151 | 650 |
| R6-0 | 21.17 | 65.96 | 87.13 | 211 | 180 |
| R7-0 | 31.21 | 118.97 | 150.18 | 183 | 290 |
| E1-0 | 683.49 | 252.45 | 935.93 | 213 | 240 |
| E3-0 | 13.88 | 53.56 | 67.44 | 114 | 190 |
| E4-0 | 127.45 | 162.61 | 290.06 | 224 | 130 |
| E5-0 | 53.54 | 135.57 | 189.11 | 132 | 93 |
| E6-0 | 60.81 | 141.02 | 201.83 | 156 | 100 |
| Profile | | | | | |
| R1-4 | 23.78 | 82.25 | 106.04 | 71 | 930 |
| R1-8 | 32.33 | 113.52 | 145.85 | -88 | 1900 |
| R2-4 | 9.60 | 41.72 | 51.31 | 116 | 1200 |
| R2-8 | 3.54 | 29.15 | 32.69 | 58 | 1100 |
| R2-12 | 14.72 | 65.91 | 80.63 | 11 | 2400 |
| E1-4 | 52.64 | 94.83 | 147.47 | 201 | 1000 |
| E1-8 | 11.46 | 65.24 | 76.70 | 176 | 910 |
| E1-12 | 5.12 | 81.69 | 86.81 | 122 | 1200 |
| E1-16 | 12.28 | 55.56 | 67.85 | 54 | 1100 |
| E1-20 | 11.17 | 45.58 | 56.76 | 30 | 1100 |
| E4-4 | 58.58 | 97.35 | 155.93 | 162 | 1000 |
| E4-8 | 35.69 | 65.75 | 101.44 | 88 | 900 |
| E4-12 | 8.60 | 47.25 | 55.85 | 78 | 1300 |
| E4-16 | 5.89 | 37.93 | 43.82 | 55 | 1700 |
| E4-20 | 7.43 | 34.49 | 41.92 | -41 | 2000 |

16-May-01

| No. | Chl a, µg/g | Phaeo., µg/g | Total | $Eh_{NHE}$, mV | $S^{=}$, µM |
|---|---|---|---|---|---|
| Surface | | | | | |
| R2-0 | 25.20 | 120.48 | 145.68 | 147 | 21 |
| R3-0 | 49.42 | 159.89 | 209.31 | 183 | 21 |
| R5-0 | 6.13 | 35.35 | 41.47 | 122 | 130 |
| R6-0 | 34.82 | 87.52 | 122.34 | 154 | 1100 |
| R8-0 | 34.72 | 153.45 | 188.17 | 107 | 180 |
| E1-0 | 62.83 | 134.47 | 197.3 | 149 | 520 |
| E4-0 | 55.86 | 67.65 | 123.51 | 166 | 1000 |
| E7-0 | 158.61 | 195.19 | 353.8 | 244 | 180 |
| E9-0 | 108.73 | 129.07 | 237.8 | 130 | 300 |
| E10-0 | 14.98 | 125.47 | 140.44 | 194 | 1900 |
| Profile | | | | | |
| R5-4 | 28.93 | 144.9 | 173.84 | 55 | 1100 |
| R6-4 | 16.00 | 103 | 119 | 118 | 1600 |
| R6-8 | 6.84 | 36.95 | 43.79 | 81 | 1800 |
| E7-4 | 37.64 | 138.97 | 176.6 | 148 | 1000 |
| E7-8 | 18.85 | 84.03 | 102.88 | 139 | 1800 |
| E7-12 | 13.43 | 60.13 | 73.55 | 81 | 2200 |
| E7-16 | 11.9 | 61.18 | 73.08 | 77 | 2300 |
| E10-4 | 21.97 | 85.64 | 107.6 | 157 | 2600 |
| E10-8 | 9.64 | 52.09 | 61.73 | 171 | 3400 |
| E10-12 | 13.22 | 69.5 | 82.72 | 95 | 3400 |
| E10-16 | 8.54 | 40.08 | 48.62 | 37 | 3800 |
| E10-20 | 6.33 | 35.46 | 41.79 | 84 | 3800 |

27-June-01

| No. | Chl a, µg/g | Phaeo., µg/g | Total | $Eh_{NHE}$, mV | $S^{=}$, µM |
|---|---|---|---|---|---|
| Surface | | | | | |
| R1-0 | 0.49 | 6.24 | 6.73 | 122 | 100 |
| R2-0 | 16.60 | 57.93 | 74.54 | 171 | 1000 |
| R3-0 | 38.62 | 95.90 | 134.52 | 139 | 130 |
| R4-0 | 25.30 | 80.03 | 105.32 | 97 | 600 |
| R5-0 | 26.58 | 76.03 | 102.61 | 84 | 340 |
| E6-0 | 66.72 | 97.23 | 163.94 | 82 | 130 |
| E7-0 | 371.23 | 263.69 | 634.92 | 133 | 170 |
| E8-0 | 127.53 | 138.33 | 265.86 | 78 | 180 |
| E9-0 | 41.66 | 84.22 | 125.88 | 172 | 810 |
| E10-0 | 87.32 | 99.71 | 187.03 | 84 | 150 |
| Profiles | | | | | |
| R1-4 | 17.05 | 50.35 | 67.39 | 52 | 650 |
| R1-08 | 144.54 | 560.00 | 704.55 | 43 | 1200 |
| R2-4 | 6.21 | 31.18 | 37.40 | 16 | 1200 |
| R2-8 | 7.45 | 41.32 | 48.77 | -42 | 1100 |
| E7-4 | 12.00 | 41.01 | 53.01 | 158 | 1600 |
| E7-8 | 20.95 | 79.63 | 100.58 | 98 | 2100 |
| E7-12 | 83.57 | 208.24 | 291.81 | 24 | 2500 |
| E7-16 | 326.41 | 610.78 | 937.20 | 0 | 1800 |
| E7-20 | 46.52 | 137.49 | 184.01 | 15 | 2100 |
| E9-4 | 32.65 | 123.11 | 155.77 | 158 | 880 |
| E9-8 | 24.47 | 80.30 | 104.77 | 126 | 620 |
| E9-12 | 26.16 | 90.38 | 116.54 | 53 | 890 |
| E9-16 | 12.19 | 50.25 | 62.45 | 36 | 1100 |
| E9-20 | 15.51 | 50.03 | 65.54 | 17 | 1200 |

19-July-01

| No. | Chl a, µg/g | Phaeo., µg/g | Total | $Eh_{NHE}$, mV | $S^{=}$, µM | EHAA mg(AA)/g | Carbon vial # |
|---|---|---|---|---|---|---|---|
| Surface | | | | | | | |
| R6-0 | 25.45 | 101.23 | 126.68 | 25 | 340 | 1.16 | 2696 |
| R7-0 | 20.99 | 78.43 | 99.42 | 122 | 870 | 1.37 | 2697 |
| R8-0 | 50.42 | 140.97 | 191.39 | 146 | 210 | 1.55 | 2709 |
| R9-0 | 41.80 | 139.36 | 181.17 | 150 | 60 | 1.47 | 2698 |
| R10-0 | 28.17 | 109.88 | 138.05 | 84 | 1200 | 1.02 | 2705 |
| E1-0 | 162.54 | 263.77 | 426.30 | 92 | 51 | 1.54 | 2693 |
| E2-0 | 140.45 | 299.25 | 439.70 | 78 | 180 | 1.93 | 2694 |
| E3-0 | 224.81 | 332.87 | 557.68 | 96 | 110 | 2.14 | 2695 |
| E4-0 | 145.49 | 224.36 | 369.85 | 111 | 1100 | 1.58 | 2681 |
| E5-0 | 123.83 | 208.69 | 332.52 | 167 | 130 | 2.06 | 2687 |
| Profile | | | | | | | |
| R8-4 | 22.98 | 79.04 | 102.02 | 104 | 3300 | 0.94 | 2710 |
| R10-4 | 42.55 | 141.16 | 183.71 | 173 | 1000 | 1.53 | 2706 |
| R10-8 | 18.27 | 58.14 | 76.42 | 96 | 3700 | 0.79 | 2707 |
| R10-12 | 7.81 | 29.40 | 37.21 | 89 | 4100 | 0.51 | 2708 |
| E4-4 | 132.11 | 250.36 | 382.48 | 106 | 360 | 1.55 | 2682 |
| E4-8 | 41.54 | 136.80 | 178.34 | 164 | 2000 | 1.35 | 2683 |
| E4-12 | 16.93 | 66.18 | 83.11 | 139 | 1100 | 1.10 | 2684 |
| E4-16 | 14.11 | 48.65 | 62.76 | 164 | 1100 | 1.01 | 2685 |
| E4-20 | 7.28 | 38.32 | 45.59 | 94 | 1700 | 0.88 | 2686 |
| E5-4 | 96.91 | 184.85 | 281.76 | 162 | 1100 | 1.49 | 2688 |
| E5-8 | 24.84 | 75.83 | 100.67 | 179 | 2300 | 1.30 | 2689 |
| E5-12 | 10.90 | 47.16 | 58.07 | 95 | 2900 | 1.03 | 2690 |
| E5-16 | 10.42 | 35.96 | 46.38 | 58 | 3700 | 0.96 | 2691 |
| E5-20 | 8.50 | 35.69 | 44.19 | 108 | 3700 | 0.99 | 2692 |

22-Aug-01

| No. | Chl a, µg/g | Phaeo., µg/g | Total | $Eh_{NHE}$, mV | $S^{=}$, µM | Carbon vial# |
|---|---|---|---|---|---|---|
| Surface | | | | | | |
| R1-0 | 6.11 | 29.48 | 35.58 | -92 | 120 | 2727 |
| R2-0 | 20.98 | 84.76 | 105.74 | -67 | 45 | 2723 |
| R3-0 | 20.96 | 54.58 | 75.54 | -88 | 30 | 2736 |
| R4-0 | 14.82 | 48.33 | 63.15 | -79 | 16 | 2732 |
| R5-0 | 15.91 | 59.72 | 75.63 | -94 | 390 | 2718 |
| E6-0 | 169.09 | 173.87 | 342.95 | -88 | 380 | 2717 |
| E7-0 | 31.12 | 117.47 | 148.59 | -91 | 120 | 2737 |
| E8-0 | 97.27 | 148.59 | 245.86 | -65 | 73 | 2731 |
| E9-0 | 24.76 | 98.02 | 122.78 | -79 | 180 | 2734 |
| E10-0 | 46.30 | 118.31 | 164.61 | -95 | 130 | 2728 |
| Profile | | | | | | |
| R2-4 | 27.61 | 8.54 | 36.15 | -93 | 1000 | 2729 |
| R2-8 | 7.22 | 36.38 | 43.60 | -108 | 1300 | 2733 |
| R5-4 | 6.52 | 23.56 | 30.08 | -103 | 1100 | 2719 |
| R5-8 | 2.89 | 14.19 | 17.08 | -100 | 1300 | 2722 |
| E6-4 | 67.72 | 99.54 | 167.25 | -92 | 210 | 2720 |
| E6-8 | 39.05 | 101.45 | 140.50 | -106 | 1100 | 2715 |
| E6-12 | 19.06 | 67.78 | 86.84 | -123 | 1000 | 2704 |
| E6-16 | 16.65 | 51.46 | 68.12 | -140 | 1000 | 2712 |
| E6-20 | 17.68 | 71.50 | 89.18 | -130 | 1100 | ? |
| E10-4 | 21.45 | 53.09 | 74.54 | -96 | 200 | 2724 |
| E10-8 | 19.56 | 73.04 | 92.60 | -91 | 810 | 2721 |
| E10-12 | 19.92 | 67.14 | 87.07 | -105 | 1000 | 2730 |
| E10-16 | 11.82 | 52.26 | 64.08 | -113 | 1100 | 2725 |
| E10-20 | 16.76 | 46.65 | 63.41 | -93 | 1500 | 2762 |

19-Sept-01

| No. | Chl a, µg/g | Phaeo., µg/g | Total | $Eh_{NHE}$, mV | $S^{=}$, µM | Carbon vial # |
|---|---|---|---|---|---|---|
| Surface | | | | | | |
| R1-0 | 10.29 | 50.49 | 60.78 | 174 | 1100 | 2750 |
| R2-0 | 6.17 | 41.48 | 47.64 | 97 | 2000 | 2756 |
| R3-0 | 15.15 | 97.14 | 112.30 | 42 | 520 | 2751 |
| R4-0 | 7.29 | 40.30 | 47.59 | 41 | 1600 | 2752 |
| R10-0 | 3.75 | 24.67 | 28.43 | 40 | 810 | 2738 |
| E5-0 | 38.88 | 186.62 | 225.50 | 27 | 310 | 2753 |
| E6-0 | 21.50 | 117.83 | 139.33 | 44 | 30 | 2744 |
| E7-0 | 36.72 | 150.10 | 186.82 | 109 | 110 | 2742 |
| E8-0 | 42.33 | 177.01 | 219.35 | 44 | 260 | 2754 |
| E9-0 | 31.80 | 109.07 | 140.87 | 30 | 720 | 2755 |
| Profile | | | | | | |
| R2-4 | 3.87 | 30.60 | 34.47 | 8 | 1900 | 2757 |
| R2-8 | 3.81 | 25.63 | 29.44 | 6 | 2400 | 2758 |
| R2-12 | 3.14 | 17.93 | 21.07 | 11 | 3600 | 2759 |
| R10-4 | 4.19 | 29.18 | 33.37 | -2 | 1800 | 2739 |
| R10-8 | 6.32 | 45.42 | 51.74 | -23 | 2500 | 2740 |
| R10-12 | 3.72 | 23.69 | 27.41 | -32 | 3300 | 2741 |
| E6-4 | 30.37 | 72.09 | 102.45 | -101 | 600 | 2745 |
| E6-8 | 28.78 | 71.84 | 100.62 | -127 | 1100 | 2746 |
| E6-12 | 8.33 | 48.11 | 56.44 | -128 | 1200 | 2747 |
| E6-16 | 8.39 | 46.17 | 54.56 | -122 | 1200 | 2748 |
| E7-4 | 33.10 | 81.22 | 114.32 | 73 | 910 | 2743 |
| E7-8 | 31.46 | 82.87 | 114.33 | 55 | 1200 | 2749 |
| E7-12 | 26.51 | 93.73 | 120.24 | 7 | 1300 | 2760 |
| E7-16 | 9.83 | 70.09 | 79.92 | -29 | 1400 | 2761 |
| E7-20 | 7.03 | 40.95 | 47.98 | -12 | 2400 | 2762 |

Appendix 2. Sediment interfacial temperatures in degrees centigrade, as daily average X and standard error S.E., at station E from 30th March to 19th September, 2001.

| | March | | April | | May | | June | | July | | August | | September | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | X | S.E | X | S.E. | X | S.E. | X | S.E. | X | S.E. | X | S.E. | X | S.E. |
| 1 | | | 2.60 | 0.00 | 4.11 | 0.00 | 5.84 | 0.01 | 8.73 | 0.02 | 10.97 | 0.02 | 12.26 | 0.00 |
| 2 | | | 2.60 | 0.00 | 4.27 | 0.00 | 5.98 | 0.01 | 8.79 | 0.03 | 11.27 | 0.02 | 12.26 | 0.00 |
| 3 | | | 2.48 | 0.01 | 4.18 | 0.01 | 6.17 | 0.01 | 8.56 | 0.02 | 11.34 | 0.02 | 12.34 | 0.01 |
| 4 | | | 2.42 | 0.01 | 4.22 | 0.01 | 6.44 | 0.01 | 8.68 | 0.01 | 11.58 | 0.02 | 12.30 | 0.01 |
| 5 | | | 2.57 | 0.01 | 4.17 | 0.01 | 6.62 | 0.01 | 8.82 | 0.02 | 11.80 | 0.02 | 12.13 | 0.01 |
| 6 | | | 2.62 | 0.01 | 4.30 | 0.01 | 6.68 | 0.00 | 9.08 | 0.02 | 11.84 | 0.02 | 12.02 | 0.01 |
| 7 | | | 2.76 | 0.00 | 4.66 | 0.00 | 6.71 | 0.01 | 9.20 | 0.01 | 11.72 | 0.02 | 11.94 | 0.01 |
| 8 | | | 2.88 | 0.01 | 4.38 | 0.01 | 6.80 | 0.01 | 9.31 | 0.01 | 11.77 | 0.02 | 11.84 | 0.01 |
| 9 | | | 2.83 | 0.01 | 4.50 | 0.01 | 6.82 | 0.02 | 9.39 | 0.01 | 11.68 | 0.02 | 11.94 | 0.01 |
| 10 | | | 2.76 | 0.00 | 4.54 | 0.00 | 6.88 | 0.01 | 9.29 | 0.02 | 11.67 | 0.01 | 12.01 | 0.01 |
| 11 | | | 2.85 | 0.01 | 4.63 | 0.01 | 7.17 | 0.02 | 9.47 | 0.00 | 11.64 | 0.02 | 12.06 | 0.01 |
| 12 | | | 3.02 | 0.01 | 4.91 | 0.01 | 7.58 | 0.03 | 9.60 | 0.01 | 11.83 | 0.02 | 12.11 | 0.00 |
| 13 | | | 3.07 | 0.00 | 4.91 | 0.00 | 7.88 | 0.01 | 9.75 | 0.02 | 12.05 | 0.02 | 12.24 | 0.01 |
| 14 | | | 3.09 | 0.01 | 4.69 | 0.01 | 7.77 | 0.02 | 9.96 | 0.02 | 12.00 | 0.02 | 12.38 | 0.01 |
| 15 | | | 3.07 | 0.00 | 4.58 | 0.00 | 7.88 | 0.02 | 10.22 | 0.01 | 12.00 | 0.01 | 12.31 | 0.01 |
| 16 | | | 3.07 | 0.00 | 5.35 | 0.00 | 7.77 | 0.02 | 10.14 | 0.02 | 12.12 | 0.02 | 12.30 | 0.01 |
| 17 | | | 3.13 | 0.01 | 5.33 | 0.01 | 8.13 | 0.03 | 10.43 | 0.02 | 12.29 | 0.03 | 12.23 | 0.01 |
| 18 | | | 3.23 | 0.00 | 5.44 | 0.00 | 8.20 | 0.03 | 10.59 | 0.02 | 12.53 | 0.01 | 12.21 | 0.01 |
| 19 | | | 3.14 | 0.01 | 5.25 | 0.01 | 8.11 | 0.02 | 10.62 | 0.01 | 12.41 | 0.02 | 12.23 | 0.01 |
| 20 | | | 3.20 | 0.01 | 4.86 | 0.01 | 8.24 | 0.02 | 10.84 | 0.02 | 12.35 | 0.01 | | |
| 21 | | | 3.35 | 0.01 | 5.02 | 0.01 | 8.17 | 0.02 | 11.17 | 0.02 | 12.35 | 0.01 | | |
| 22 | | | 3.55 | 0.00 | 5.14 | 0.00 | 8.26 | 0.02 | 11.26 | 0.02 | 12.15 | 0.01 | | |
| 23 | | | 3.51 | 0.01 | 5.33 | 0.01 | 8.49 | 0.01 | 10.90 | 0.02 | 12.06 | 0.01 | | |
| 24 | | | 3.61 | 0.01 | 5.43 | 0.01 | 8.53 | 0.00 | 10.75 | 0.02 | 11.87 | 0.01 | | |
| 25 | | | 3.61 | 0.01 | 6.00 | 0.01 | 8.47 | 0.01 | 10.65 | 0.02 | 11.89 | 0.01 | | |
| 26 | | | 3.78 | 0.01 | 6.10 | 0.01 | 8.42 | 0.01 | 10.48 | 0.02 | 11.96 | 0.01 | | |
| 27 | | | 3.87 | 0.00 | 6.03 | 0.00 | 8.60 | 0.02 | 10.35 | 0.01 | 11.80 | 0.02 | | |
| 28 | | | 4.03 | 0.01 | 6.07 | 0.01 | 8.58 | 0.01 | 10.42 | 0.01 | 11.64 | 0.00 | | |
| 29 | | | 4.09 | 0.01 | 6.08 | 0.01 | 8.61 | 0.01 | 10.49 | 0.01 | 11.73 | 0.01 | | |
| 30 | 2.60 | 0.00 | 3.95 | 0.01 | 6.09 | 0.01 | 8.67 | 0.02 | 10.64 | 0.01 | 11.90 | 0.01 | | |
| 31 | 2.63 | 0.01 | | | 5.98 | 0.02 | | | 10.75 | 0.01 | 12.13 | 0.01 | | |

Appendix 3. Climatic data for Point Lepreau, New Brunswick (45°16'N, 66°04'W). Wind direction, as compass points it is from; wind in km/h, temperature as °C and the percentage relative humidity in the air. Entries are for the 24-h period prior to sampling.

| Date DST | Wind direction | Speed, km/h | Temperature, °C | Relative humidity, % |
|---|---|---|---|---|
| SEPTEMBER | | | | |
| 2000/9/19 | | | | |
| Time | | | | |
| 12:00 | 200 | 17 | 16 | 93 |
| 13:00 | 190 | 15 | 15.6 | 93 |
| 14:00 | 200 | 19 | 15.6 | 93 |
| 15:00 | 180 | 9 | 15.2 | 96 |
| 16:00 | 190 | 15 | 15.2 | 96 |
| 17:00 | 220 | 11 | 15.3 | 97 |
| 18:00 | 200 | 9 | 14.8 | 98 |
| 19:00 | 190 | 6 | 14.5 | 99 |
| 20:00 | 200 | 4 | 14.6 | 99 |
| 21:00 | 210 | 7 | 14.5 | 99 |
| 22:00 | 200 | 6 | 14.6 | 99 |
| 23:00 | 200 | 6 | 14.7 | 99 |
| 2000/9/20 | 190 | 7 | 14.5 | 99 |
| 0:00 | | | | |
| 1:00 | 200 | 9 | 14.6 | 99 |
| 2:00 | 210 | 7 | 14.4 | 99 |
| 3:00 | 200 | 7 | 14.2 | 99 |
| 4:00 | 190 | 9 | 14.2 | 99 |
| 5:00 | 310 | 4 | 14 | 99 |
| 6:00 | 20 | 7 | 14.3 | 99 |
| 7:00 | 60 | 9 | 15.1 | 99 |
| 8:00 | 60 | 11 | 15.1 | 100 |
| 9:00 | 60 | 13 | 16 | 100 |
| 10:00 | 50 | 17 | 16.3 | 100 |
| 11:00 | 50 | 13 | 16.8 | 97 |
| 12:00 | 70 | 13 | 17.8 | 94 |
| OCTOBER | | | | |
| 2000/10/30 | | | | |
| 9:00 | 30 | 15 | 6 | 90 |
| 10:00 | 40 | 17 | 7.3 | 84 |
| 11:00 | 30 | 15 | 8.1 | 82 |
| 12:00 | 30 | 13 | 8.5 | 88 |
| 13:00 | 20 | 17 | 8.4 | 93 |
| 14:00 | 30 | 13 | 8.8 | 95 |
| 15:00 | 30 | 30 | 9.6 | 93 |
| 16:00 | 30 | 28 | 9.8 | 92 |
| 17:00 | 40 | 28 | 9.6 | 92 |
| 18:00 | 40 | 33 | 9.7 | 91 |

| Date DST | Wind direction | Speed, km/h | Temperature, °C | Relative humidity, % |
|---|---|---|---|---|
| 19:00 | 40 | 32 | 9.4 | 91 |
| 20:00 | 40 | 26 | 8.9 | 92 |
| 21:00 | 40 | 28 | 8.3 | 92 |
| 22:00 | 30 | 22 | 7.7 | 93 |
| 23:00 | 40 | 24 | 7.6 | 92 |
| 2000/10/31 | 30 | 26 | 7.3 | 90 |
| 0:00 | | | | |
| 1:00 | 30 | 24 | 7.1 | 88 |
| 2:00 | 30 | 28 | 6.9 | 88 |
| 3:00 | 30 | 24 | 6.5 | 89 |
| 4:00 | 30 | 22 | 6.3 | 90 |
| 5:00 | 40 | 24 | 6.5 | 90 |
| 6:00 | 40 | 30 | 6.5 | 92 |
| 7:00 | 40 | 20 | 7 | 91 |
| 8:00 | 50 | 24 | 7.1 | 90 |
| NOVEMBER | | | | |
| 2000/11/29 | | | | |
| 9:00 | 350 | 6 | 2.1 | 95 |
| 10:00 | 320 | 4 | 2.6 | 95 |
| 11:00 | 330 | 2 | 3.5 | 93 |
| 12:00 | 290 | 9 | 4 | 91 |
| 13:00 | 290 | 6 | 4.9 | 90 |
| 14:00 | 300 | 7 | 5.1 | 88 |
| 15:00 | 290 | 9 | 5 | 84 |
| 16:00 | 290 | 7 | 4.7 | 87 |
| 17:00 | 320 | 4 | 4.2 | 89 |
| 18:00 | 300 | 7 | 4.4 | 89 |
| 19:00 | 290 | 7 | 4.5 | 84 |
| 20:00 | 290 | 6 | 4.4 | 85 |
| 21:00 | 300 | 6 | 3.1 | 91 |
| 22:00 | 290 | 6 | 4.3 | 91 |
| 23:00 | 270 | 7 | 4.3 | 91 |
| 0:00 | 300 | 7 | 3.7 | 92 |
| 2000/11/30 | 310 | 6 | 3.1 | 93 |
| 1:00 | | | | |
| 2:00 | 310 | 4 | 2.7 | 93 |
| 3:00 | 310 | 6 | 2.7 | 93 |
| 4:00 | 310 | 6 | 2.3 | 93 |
| 5:00 | 330 | 7 | 1.9 | 93 |
| 6:00 | 320 | 6 | 0.1 | 93 |
| 7:00 | 330 | 9 | 0.9 | 95 |
| 8:00 | 350 | 11 | 1.3 | 93 |
| JANUARY | | | | |
| 2001/01/03 | | | | |
| 12:00 | 330 | 17 | -6.9 | 54 |
| 13:00 | 10 | 9 | -6.5 | 55 |
| 14:00 | 320 | 15 | -6.5 | 55 |

| Date DST | Wind direction | Speed, km/h | Temperature, °C | Relative humidity, % |
|---|---|---|---|---|
| 15:00 | 340 | 9 | -6 | 57 |
| 16:00 | 320 | 7 | -6.8 | 59 |
| 17:00 | 350 | 2 | -8.6 | 69 |
| 18:00 | 360 | 6 | -9.8 | 76 |
| 19:00 | 10 | 9 | -9.8 | 77 |
| 20:00 | 350 | 9 | -9.7 | 77 |
| 21:00 | 30 | 7 | -10.7 | 79 |
| 22:00 | 350 | 7 | -10.4 | 79 |
| 23:00 | 10 | 9 | -11.5 | 83 |
| 2001/01/04 0:00 | 360 | 11 | -10 | 75 |
| 1:00 | 10 | 11 | -10 | 75 |
| 2:00 | 20 | 9 | -10 | 75 |
| 3:00 | 360 | 7 | -9.8 | 75 |
| 4:00 | 360 | 7 | -10.1 | 75 |
| 5:00 | 30 | 9 | -9.2 | 74 |
| 6:00 | 20 | 9 | -8.6 | 78 |
| 7:00 | 20 | 11 | -7.2 | 87 |
| 8:00 | 160 | 30 | -1.1 | 90 |
| 9:00 | 150 | 33 | -0.4 | 95 |
| 10:00 | 150 | 41 | 0 | 96 |
| 11:00 | 150 | 44 | 0.7 | 97 |
| 12:00 | 240 | 13 | 0.2 | 91 |
| FEBRUARY | | | | |
| 2001/02/27 | | | | |
| 9:00 | 320 | 26 | -6 | 64 |
| 10:00 | 320 | 22 | -5 | 63 |
| 11:00 | 320 | 11 | -3.3 | 60 |
| 12:00 | 300 | 15 | -1.2 | 53 |
| 13:00 | 290 | 15 | 0 | 52 |
| 14:00 | 300 | 17 | 0.4 | 47 |
| 15:00 | 290 | 19 | 1 | 43 |
| 16:00 | 300 | 20 | 0.9 | 42 |
| 17:00 | 290 | 17 | 0.8 | 43 |
| 18:00 | 320 | 20 | -0.8 | 44 |
| 19:00 | 310 | 20 | -1.8 | 45 |
| 20:00 | 310 | 17 | -2.8 | 47 |
| 21:00 | 300 | 15 | -4 | 53 |
| 22:00 | 310 | 15 | -4.9 | 53 |
| 23:00 | 310 | 24 | -5.8 | 53 |
| 2001/02/28 0:00 | 300 | 15 | -6.8 | 56 |
| 1:00 | 300 | 17 | -7.6 | 58 |
| 2:00 | 310 | 13 | -8.7 | 63 |
| 3:00 | 320 | 15 | -9.6 | 65 |
| 4:00 | 330 | 9 | -10.5 | 66 |
| 5:00 | 310 | 9 | -10.9 | 67 |

| Date DST | Wind direction | Speed, km/h | Temperature, °C | Relative humidity, % |
|---|---|---|---|---|
| 6:00 | 320 | 9 | -11.6 | 67 |
| 7:00 | 320 | 20 | -12.3 | 60 |
| 8:00 | 310 | 22 | -12.4 | 58 |
| MARCH | | | | |
| 2001/03/29 | | | | |
| 10:00 | 250 | 9 | 4.7 | 50 |
| 11:00 | 220 | 9 | 3.8 | 64 |
| 12:00 | 220 | 15 | 4.4 | 66 |
| 13:00 | 220 | 15 | 5.2 | 60 |
| 14:00 | 210 | 15 | 5.2 | 54 |
| 15:00 | 190 | 20 | 4.2 | 65 |
| 16:00 | 210 | 15 | 4.2 | 59 |
| 17:00 | 220 | 11 | 4 | 61 |
| 18:00 | 210 | 15 | 2.9 | 66 |
| 19:00 | 220 | 9 | 2.7 | 70 |
| 20:00 | 220 | 9 | 2.4 | 75 |
| 21:00 | 220 | 11 | 2.4 | 81 |
| 22:00 | 190 | 7 | 2.2 | 83 |
| 23:00 | 210 | 6 | 2.4 | 83 |
| 2001/03/30 | 210 | 7 | 2.5 | 82 |
| 0:00 | | | | |
| 1:00 | 250 | 6 | 2.4 | 84 |
| 2:00 | 240 | 2 | 1.2 | 85 |
| 3:00 | 260 | 4 | -0.6 | 93 |
| 4:00 | 290 | 2 | -1.9 | 94 |
| 5:00 | 310 | 4 | -1.8 | 94 |
| 6:00 | 320 | 4 | -1.9 | 95 |
| 7:00 | 0 | 0 | -1.6 | 94 |
| 8:00 | 0 | 0 | 2.9 | 82 |
| 9:00 | 100 | 7 | 2.7 | 82 |
| APRIL | | | | |
| 2001/04/29 | | | | |
| 12:00 | 300 | 19 | 9.4 | 23 |
| 13:00 | 320 | 19 | 10.4 | 19 |
| 14:00 | 300 | 17 | 10.7 | 19 |
| 15:00 | 330 | 19 | 11.1 | 17 |
| 16:00 | 330 | 19 | 11.5 | 17 |
| 17:00 | 330 | 19 | 11.7 | 17 |
| 18:00 | 330 | 19 | 11.2 | 19 |
| 19:00 | 330 | 7 | 9.9 | 23 |
| 20:00 | 340 | 6 | 5.6 | 35 |
| 21:00 | 320 | 4 | 2.1 | 50 |
| 22:00 | 320 | 7 | 1.7 | 48 |
| 23:00 | 320 | 7 | 1 | 52 |
| 2001/04/30 | 320 | 9 | 0.9 | 53 |
| 0:00 | | | | |
| 1:00 | 320 | 9 | 0.7 | 54 |

| Date DST | Wind direction | Speed, km/h | Temperature, °C | Relative humidity, % |
|---|---|---|---|---|
| 2:00 | 0 | 0 | -0.7 | 68 |
| 3:00 | 300 | 7 | -0.2 | 62 |
| 4:00 | 340 | 9 | 1.2 | 57 |
| 5:00 | 310 | 9 | 2.6 | 56 |
| 6:00 | 310 | 7 | 3.7 | 45 |
| 7:00 | 00 | 0 | 4.4 | 58 |
| 8:00 | 130 | 2 | 5 | 60 |
| 9:00 | 190 | 7 | 5.8 | 65 |
| 10:00 | 170 | 4 | 8.4 | 51 |
| 11:00 | 180 | 11 | 8.9 | 67 |
| MAY | | | | |
| 2001/05/15 | | | | |
| 13:00 | 60 | 20 | 9.3 | 90 |
| 14:00 | 70 | 20 | 9.4 | 90 |
| 15:00 | 60 | 17 | 9.7 | 91 |
| 16:00 | 60 | 19 | 10.4 | 86 |
| 17:00 | 60 | 19 | 9.6 | 86 |
| 18:00 | 70 | 19 | 9.7 | 85 |
| 19:00 | 60 | 19 | 9.7 | 89 |
| 20:00 | 50 | 15 | 9.7 | 90 |
| 21:00 | 40 | 19 | 9.7 | 90 |
| 22:00 | 30 | 13 | 9.6 | 93 |
| 23:00 | 50 | 19 | 9.7 | 93 |
| 2001/05/16 | 40 | 11 | 9.5 | 92 |
| 0:00 | | | | |
| 1:00 | 40 | 15 | 9.1 | 88 |
| 2:00 | 30 | 19 | 9.1 | 84 |
| 3:00 | 20 | 15 | 8.7 | 87 |
| 4:00 | 10 | 19 | 8.2 | 89 |
| 5:00 | 30 | 15 | 8.2 | 87 |
| 6:00 | 30 | 17 | 8.3 | 86 |
| 7:00 | 20 | 17 | 8.6 | 85 |
| 8:00 | 30 | 17 | 9.2 | 83 |
| 9:00 | 30 | 22 | 10.1 | 78 |
| 10:00 | 30 | 26 | 11.2 | 73 |
| 11:00 | 40 | 24 | 11.7 | 69 |
| 12:00 | 30 | 17 | 11.5 | 68 |
| JUNE | | | | |
| 2001/06/26 | | | | |
| 11:00 | 140 | 4 | 21.4 | 76 |
| 12:00 | 100 | 4 | 22.3 | 73 |
| 13:00 | 150 | 6 | 20 | 78 |
| 14:00 | 100 | 7 | 19.1 | 81 |
| 15:00 | 100 | 7 | 18.7 | 82 |
| 16:00 | 110 | 9 | 18.5 | 77 |
| 17:00 | 130 | 4 | 20.1 | 76 |
| 18:00 | 110 | 4 | 18.1 | 83 |

| Date DST | Wind direction | Speed, km/h | Temperature, °C | Relative humidity, % |
|---|---|---|---|---|
| 19:00 | 0 | 0 | 17.1 | 86 |
| 20:00 | 0 | 0 | 16.3 | 91 |
| 21:00 | 280 | 7 | 16.5 | 87 |
| 22:00 | 280 | 9 | 16.5 | 86 |
| 23:00 | 260 | 4 | 16.9 | 86 |
| 2001/06/27 | 280 | 6 | 15.5 | 88 |
| 0:00 | | | | |
| 1:00 | 280 | 4 | 14.4 | 90 |
| 2:00 | 280 | 7 | 12.5 | 92 |
| 3:00 | 290 | 6 | 12.3 | 93 |
| 4:00 | 290 | 6 | 11.9 | 92 |
| 5:00 | 310 | 11 | 11.8 | 93 |
| 6:00 | 270 | 11 | 14 | 88 |
| 7:00 | 270 | 11 | 16.4 | 84 |
| 8:00 | 260 | 11 | 17.8 | 78 |
| 9:00 | 240 | 11 | 20.9 | 72 |
| 10:00 | 230 | 11 | 21.7 | 67 |
| JULY | | | | |
| 2001/07/25 | | | | |
| 11:00 | 240 | 9 | 24.4 | 59 |
| 12:00 | 270 | 9 | 27.2 | 48 |
| 13:00 | 230 | 7 | 24.1 | 58 |
| 14:00 | 190 | 4 | 21.3 | 64 |
| 15:00 | 220 | 9 | 25.9 | 48 |
| 16:00 | 280 | 11 | 26.2 | 47 |
| 17:00 | 250 | 7 | 21.9 | 59 |
| 18:00 | 280 | 2 | 20.6 | 65 |
| 19:00 | 250 | 4 | 20.3 | 68 |
| 20:00 | 280 | 4 | 20.3 | 66 |
| 21:00 | 310 | 9 | 18 | 76 |
| 22:00 | 320 | 7 | 17.9 | 80 |
| 23:00 | 280 | 7 | 16.4 | 86 |
| 0:00 | 260 | 7 | 15.9 | 90 |
| 2001/07/26 | 290 | 7 | 15 | 89 |
| 0:00 | | | | |
| 1:00 | | | | |
| 2:00 | 290 | 9 | 15.7 | 87 |
| 3:00 | 300 | 6 | 15.1 | 90 |
| 4:00 | 300 | 7 | 15.5 | 88 |
| 5:00 | 320 | 11 | 15.9 | 74 |
| 6:00 | 330 | 11 | 16 | 69 |
| 7:00 | 320 | 9 | 16.1 | 68 |
| 8:00 | 330 | 9 | 16.7 | 63 |
| 9:00 | 340 | 9 | 17.7 | 56 |
| 10:00 | 320 | 13 | 17.3 | 57 |

| Date DST | Wind direction | Speed, km/h | Temperature, °C | Relative humidity, % |
|---|---|---|---|---|
| AUGUST | | | | |
| 2001/08/21 | | | | |
| 9:00 | 50 | 15 | 16 | 97 |
| 10:00 | 50 | 15 | 16.2 | 97 |
| 11:00 | 60 | 6 | 16.4 | 97 |
| 12:00 | 60 | 11 | 16.2 | 96 |
| 13:00 | 70 | 9 | 16.3 | 97 |
| 14:00 | 90 | 6 | 16.6 | 97 |
| 15:00 | 90 | 9 | 16 | 97 |
| 16:00 | 90 | 4 | 15.9 | 97 |
| 17:00 | 90 | 7 | 15.8 | 97 |
| 18:00 | 80 | 6 | 15.4 | 97 |
| 19:00 | 110 | 6 | 15.4 | 98 |
| 20:00 | 0 | 0 | 14.7 | 98 |
| 21:00 | 0 | 0 | 14.8 | 97 |
| 22:00 | 120 | 2 | 14.4 | 98 |
| 23:00 | 120 | 2 | 14.2 | 99 |
| 2001/08/22 | 140 | 2 | 13.7 | 98 |
| 0:00 | | | | |
| 1:00 | 300 | 2 | 13.8 | 98 |
| 2:00 | 300 | 4 | 14.7 | 98 |
| 3:00 | 90 | 2 | 13.6 | 99 |
| 4:00 | 180 | 2 | 13.8 | 99 |
| 5:00 | 260 | 4 | 14.1 | 99 |
| 6:00 | 310 | 7 | 15 | 98 |
| 7:00 | 0 | 0 | 15.4 | 99 |
| 8:00 | 0 | 0 | 14.5 | 99 |
| SEPTEMBER | 0 | | | |
| 2001/09/18 | 0 | | | |
| 8:00 | 310 | 2 | 14.8 | 81 |
| 9:00 | 140 | 2 | 14.5 | 84 |
| 10:00 | 270 | 4 | 21.1 | 59 |
| 11:00 | 190 | 9 | 16.2 | 77 |
| 12:00 | 180 | 7 | 19.1 | 64 |
| 13:00 | 180 | 9 | 17.1 | 74 |
| 14:00 | 190 | 7 | 18.2 | 69 |
| 15:00 | 270 | 7 | 21.8 | 54 |
| 16:00 | 140 | 6 | 19.9 | 64 |
| 17:00 | 10 | 11 | 23.8 | 43 |
| 18:00 | 350 | 7 | 22.2 | 48 |
| 19:00 | 340 | 9 | 20.2 | 55 |
| 20:00 | 320 | 9 | 19.5 | 58 |
| 21:00 | 360 | 6 | 17.3 | 54 |
| 22:00 | 330 | 9 | 15.7 | 59 |
| 23:00 | 10 | 6 | 14.6 | 66 |
| 2001/09/19 | 320 | 7 | 13.4 | 75 |
| 0:00 | | | | |

| Date DST | Wind direction | Speed, km/h | Temperature, °C | Relative humidity, % |
|---|---|---|---|---|
| 1:00 | 330 | 6 | 12.6 | 80 |
| 2:00 | 360 | 7 | 12.8 | 79 |
| 3:00 | 350 | 7 | 11.9 | 77 |
| 4:00 | 350 | 7 | 10.6 | 76 |
| 5:00 | 320 | 9 | 9.8 | 74 |
| 6:00 | 340 | 7 | 8 | 80 |
| 7:00 | 350 | 6 | 9.5 | 75 |

Appendix 4. Monthly SPI results as the benthic habitat quality (BHQ), RPD depths and organic enrichment (OE) indices at stations R and E in the period 30 November 2000 to 19 September 2001.

**STATION R**

| Date | Station | Photo. # | RPD depth, cm | BHQ | OE index | Core depth, cm |
|---|---|---|---|---|---|---|
| 30-Nov-00 | R5 | 77 | 6.8 | 5 | II | 14.4 |
| | R3 | 78 | | | | 13.7 |
| 4-Jan-00 | R1 | 98 | 6.8 | 7 | II | 14.4 |
| | R3 | 101 | 7.8 | 5 | II | 14.7 |
| 28-Feb-01 | R1 | 122 | 7.0 | 7 | II | 17.3 |
| | R5 | 125 | 9.7 | 7 | II | 17.2 |
| 30-Mar-01 | R5 | 139 | 3.2 | 5 | II | 15.8 |
| | R6 | 143 | 4.8 | 6 | II | 12.7 |
| 30 Apr-01 | R1 | 147 | 8.3 | 7 | II | 14.7 |
| | R2 | 151 | 2.1 | 8 | II | 16.7 |
| 16-May-01 | R6 | 152 | 4.4 | 8 | II | 13.8 |
| | R5 | 156 | 5.7 | 10 | II | 13.1 |
| 27-Jun-01 | R2 | 168 | 7.6 | | | 15.2 |
| | R1 | 173 | 6.3 | 9 | II | 12.8 |
| 19-Jul-01 | R10 | 208 | 6.5 | 7 | II | 17.4 |
| | R8 | 211 | 2.9 | 6 | II | 11 |
| 22-Aug-01 | R2 | 270 | 6.9 | 8 | II | 13.3 |
| | R5 | 273 | 5.5 | 8 | II | 15.6 |
| 19-Sept-01 | R10 | 313 | 2.0 | 6 | II | 15.8 |
| | R2 | 314 | 4.7 | 8 | II | 15.8 |

**STATION E**

| | Station | Photo. # | RPD depth, cm | BHQ | OE index | Core depth, cm |
|---|---|---|---|---|---|---|
| 30-Nov-00 | E1 | 83 | 4.6 | 5 | II | 22.7 |
| | E3 | 86 | 2.7 | 6 | II | 23.2 |
| 4-Jan-00 | E6 | 103 | | | | 24.6 |
| | E5 | 105 | | | | 24.5 |
| 28-Feb-01 | E4 | 127 | 4.3 | 6 | II | 23.5 |
| | E5 | 128 | | | | |
| 30-Mar-01 | E4 | 132 | 4.7 | 4 | II | 26.3 |
| | E1 | 137 | 5.6 | 6 | II | 24.4 |
| 30-Apr-01 | E1 | 144 | | | | |
| | E4 | 146 | | | | |
| 16-May-01 | E7 | 157 | 6.9 | 10 | II | 23.8 |
| | E10 | 160 | 4.0 | 6 | II | 23.2 |
| 27-Jun-01 | E9 | 175 | 6.6 | 10 | II | 25.6 |
| | E7 | 176 | 5.6 | 7 | II | 25.2 |
| 19-Jul-01 | E4 | 203 | 7.2 | 6 | II | 27.8 |
| | E5 | 205 | 11.2 | 7 | II | 28.6 |
| 22-Aug-01 | E6 | 279 | 7.8 | 9 | II | 23.9 |
| | E10 | 276 | 7.2 | 8 | II | 23.2 |
| 19-Sept-01 | E6 | 312 | 6.5 | 9 | II | 22.1 |
| | E7 | 311 | | | | 22.6 |

Appendix 5. Monthly macrofaunal community data at stations R and E in the period 31October 2000 to 19 September 2001. Diversities and biomasses are per 0.0789 $m^2$. To convert to per $m^2$ multiply by 12.67. LKE = station E followed by sampling month. LKR = station R followed by sampling month.

| Binomen | LKEOCT | LKENOV | LKEJAN | LKEFEB | LKEMAR | LKEAPR | LKEMAY | LKEJUN | LKEJUL | LKEAUG | LKESEPT | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Foviella affinis* | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| Nemertea (sp.2) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 2 | 7 |
| *Cerebratulus lacteus* | 2 | 2 | 1 | 1 | 3 | 1 | 5 | 2 | 2 | 3 | 3 | 25 |
| Nematoda | 66 | 7 | 54 | 16 | 26 | 7 | 16 | 5 | 0 | 36 | 125 | 358 |
| *Harmothoe imbricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 1 | 7 |
| *Hartmania moorei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| *Pholoe minuta* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Pholoe tecta* | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 1 | 0 | 6 | 0 | 11 |
| *Eteone longa* | 1 | 1 | 1 | 5 | 3 | 0 | 0 | 1 | 0 | 1 | 6 | 19 |
| *Phyllodoce mucosa* | 0 | 3 | 4 | 9 | 11 | 1 | 3 | 2 | 0 | 0 | 2 | 35 |
| *Aglaophamus neotenus* | 206 | 61 | 97 | 119 | 87 | 40 | 22 | 13 | 11 | 51 | 91 | 798 |
| *Nephtys incisa* | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 15 |
| *Ophelina acuminata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 3 |
| *Capitella capitata* | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 1 | 0 | 2 | 7 |
| *Mediomastus ambiseta* | 1 | 2 | 3 | 1 | 2 | 0 | 4 | 6 | 3 | 4 | 2 | 28 |
| *Rhodine gracilior* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| *Sternaspis scutata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Aricidea sp.* | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 6 |
| *Aricidea quadrilobata* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 3 |
| *Levensinea gracilis* | 1 | 4 | 2 | 18 | 11 | 3 | 8 | 21 | 8 | 11 | 23 | 110 |
| *Polydora sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| *Prionospio steenstrupi* | 3 | 2 | 7 | 11 | 4 | 7 | 9 | 5 | 0 | 6 | 13 | 67 |
| *Spio sp.* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Lumbrineris tenuis* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Lumbrineris impatiens* | 1 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 0 | 7 |
| *Ninoe nigripes* | 1 | 10 | 8 | 10 | 0 | 5 | 8 | 6 | 1 | 1 | 1 | 51 |
| *Leitoscoloplos robustus* | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Tharyx sp.* | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 4 | 7 |
| *Chaetozone setosa* | 4 | 1 | 5 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 14 |
| *Cossura longocirrata* | 12 | 2 | 31 | 7 | 48 | 8 | 23 | 11 | 8 | 27 | 24 | 201 |
| *Cistena granulata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Asabellides oculata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| *Melinna elizabethae* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ampharete lindstroemi* | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 6 |
| *Ampharete acutifrons* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 |

| Binomen | LKEOCT | LKENOV | LKEJAN | LKEFEB | LKEMAR | LKEAPR | LKEMAY | LKEJUN | LKEJUL | LKEAUG | LKESEPT | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Anobothrus gracilis* | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 1 | 2 | 9 |
| *Polycirrus medusa?* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 1 | 16 | 0 | 24 |
| *Terebellides stroemi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 7 | 12 | 20 |
| *Apistobranchus typicus* | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Pherusa affinis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Brada villosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 3 |
| *Euchone incolor* | 1 | 1 | 3 | 5 | 2 | 2 | 2 | 10 | 0 | 1 | 8 | 35 |
| Oligochaeta | 7 | 8 | 32 | 7 | 30 | 0 | 9 | 7 | 2 | 25 | 30 | 157 |
| *Ilyanassa trivittata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Nucula proxima* | 2 | 5 | 2 | 3 | 0 | 1 | 4 | 3 | 4 | 4 | 0 | 28 |
| *Nucula delphinodonta* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Yoldia sapotilla* | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 2 | 0 | 8 |
| *Mytilus edulis* | 7 | 3 | 2 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 4 | 20 |
| *Astare undata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 |
| *Cerastoderma pinnulatum* | 2 | 1 | 0 | 0 | 2 | 1 | 1 | 3 | 0 | 0 | 0 | 10 |
| *Solenidae* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ensis directus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 4 |
| *Mya arenaria* | 0 | 0 | 0 | 1 | 2 | 1 | 2 | 1 | 0 | 0 | 0 | 7 |
| *Thyasira flexuosa* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Balanus sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 |
| *Diastylis quadrispinosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 4 | 0 | 0 | 16 |
| *Diastylis sculpta* | 0 | 1 | 0 | 2 | 1 | 0 | 4 | 3 | 0 | 0 | 0 | 11 |
| *Ampelisca abdita* | 1 | 0 | 1 | 1 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 7 |
| *Ischyrocerus anguipes* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Monoculodes edwardsi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Monoculodes tesselatus* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 3 |
| *Dyopedos monacanthus* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 |
| *Caprellidae* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Caprella linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Crangon septemspinosa* | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Sipuncula (juv.)* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| *Priapulus caudatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Molpadia oolitica* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Biomass (gm) | 1.564 | 0.585 | 0.346 | 0.466 | 1.618 | 0.201 | 2.8 | 1.323 | 1.711 | 0.706 | 0.784 | 2192 |

| Binomen | LKROCT | LKRNOV | LKRJAN | LKRFEB | LKRMAR | LKRAPR | LKRMAY | LKRJUN | LKRJUL | LKRAUG | LKRSEPT | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Edwardsiidae | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Foviella affinis* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Nemertea (juveniles) | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| *Cerebratulus lacteus* | 1 | 0 | 4 | 2 | 4 | 2 | 2 | 2 | 2 | 1 | 0 | 20 |
| Nematoda | 24 | 85 | 29 | 178 | 250 | 427 | 32 | 49 | 11 | 66 | 313 | 1464 |
| *Harmothoe extenuata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Harmothoe imbricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 4 | 8 |
| *Hartmania moorei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Pholoe minuta* | 8 | 1 | 7 | 17 | 12 | 10 | 2 | 4 | 0 | 5 | 0 | 66 |
| *Pholoe tecta* | 0 | 4 | 9 | 7 | 4 | 2 | 0 | 1 | 2 | 1 | 1 | 31 |
| *Eteone longa* | 1 | 0 | 4 | 9 | 1 | 1 | 3 | 2 | 0 | 5 | 0 | 26 |
| *Paranaitis speciosa* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| *Phyllodoce mucosa* | 2 | 12 | 5 | 5 | 6 | 1 | 0 | 2 | 0 | 1 | 1 | 35 |
| *Sphaerosyllis sp.* | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Nereis grayi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 |
| *Nephtys incisa* | 13 | 11 | 4 | 8 | 9 | 6 | 6 | 12 | 7 | 7 | 9 | 92 |
| *Glycera capitata* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Clavodorum sp.* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Scalibregma inflatum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ophelina acuminata* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 3 |
| *Mediomastus ambiseta* | 1 | 2 | 5 | 1 | 3 | 22 | 2 | 3 | 0 | 5 | 1 | 45 |
| *Praxillella praetermissa* | 3 | 0 | 1 | 1 | 3 | 1 | 1 | 1 | 0 | 0 | 0 | 11 |
| *Rhodine gracilior* | 1 | 5 | 4 | 2 | 1 | 7 | 2 | 4 | 2 | 5 | 0 | 33 |
| *Sternaspis scutata* | 5 | 4 | 12 | 6 | 7 | 14 | 2 | 2 | 3 | 2 | 4 | 61 |
| *Aricidea sp.* | 1 | 5 | 11 | 23 | 29 | 36 | 5 | 3 | 3 | 14 | 12 | 142 |
| *Aricidea quadrilobata* | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| *Levensinea gracilis* | 17 | 12 | 19 | 16 | 35 | 34 | 4 | 12 | 0 | 14 | 18 | 181 |
| *Prionospio steenstrupi* | 0 | 0 | 2 | 2 | 2 | 6 | 0 | 0 | 0 | 0 | 1 | 13 |
| *Lumbrineris impatiens* | 6 | 8 | 8 | 6 | 15 | 7 | 0 | 3 | 5 | 11 | 7 | 76 |
| *Ninoe nigripes* | 14 | 28 | 24 | 28 | 39 | 66 | 19 | 49 | 19 | 30 | 35 | 351 |
| *Tharyx sp.* | 2 | 3 | 6 | 3 | 5 | 3 | 2 | 3 | 1 | 3 | 4 | 35 |
| *Chaetozone sp.* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| *Chaetozone setosa* | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 10 |
| *Cossura longocirrata* | 0 | 2 | 1 | 2 | 7 | 18 | 0 | 3 | 1 | 16 | 17 | 67 |
| *Galathowenia oculata* | 0 | 6 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| *Melinna elizabethae* | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 5 |
| *Ampharete lindstroemi* | 7 | 2 | 1 | 0 | 0 | 2 | 1 | 1 | 1 | 35 | 9 | 59 |

| Binomen | LKROCT | LKRNOV | LKRJAN | LKRFEB | LKRMAR | LKRAPR | LKRMAY | LKRJUN | LKRJUL | LKRAUG | LKRSEPT | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Anobothrus gracilis* | 18 | 16 | 8 | 26 | 12 | 23 | 1 | 4 | 6 | 27 | 16 | 157 |
| *Polycirrus medusa?* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 6 |
| *Terebellides stroemi* | 0 | 0 | 1 | 3 | 8 | 18 | 4 | 13 | 13 | 221 | 84 | 365 |
| *Trichobranchus glacialis* | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 4 |
| *Apistobranchus typicus* | 3 | 20 | 70 | 49 | 7 | 13 | 6 | 8 | 7 | 8 | 5 | 196 |
| *Pherusa affinis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| *Brada villosa* | 2 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 8 |
| *Diplocirrus hirsutus* | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 5 |
| *Euchone incolor* | 0 | 2 | 3 | 3 | 4 | 2 | 2 | 0 | 0 | 15 | 2 | 33 |
| Oligochaeta | 0 | 1 | 4 | 2 | 2 | 9 | 0 | 0 | 0 | 13 | 10 | 41 |
| *Frigidoalvania pelagica* | 1 | 3 | 2 | 2 | 11 | 10 | 6 | 3 | 0 | 5 | 1 | 44 |
| *Lunatia heros* | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| *Astyris zonalis* | 0 | 8 | 0 | 1 | 3 | 2 | 0 | 0 | 0 | 1 | 0 | 15 |
| *Nassarius trivittatus* | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 5 |
| *Diaphana minuta* | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Cylichna alba* | 0 | 3 | 2 | 3 | 3 | 2 | 0 | 1 | 1 | 0 | 0 | 15 |
| *Retusa obtusa* | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 3 | 2 | 12 | 1 | 21 |
| *Nucula proxima* | 3 | 16 | 25 | 18 | 18 | 28 | 8 | 5 | 14 | 24 | 7 | 166 |
| *Nucula delphinodonta* | 1 | 7 | 2 | 9 | 15 | 1 | 2 | 6 | 2 | 4 | 7 | 56 |
| *Nucula tenuis* | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 0 | 1 | 0 | 0 | 6 |
| *Nuculana tenuisulcata* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Yoldia sapotilla* | 25 | 9 | 12 | 17 | 28 | 22 | 9 | 12 | 17 | 11 | 7 | 169 |
| *Mytilus edulis* | 10 | 5 | 0 | 2 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 22 |
| *Musculus niger* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Crenella glandula* | 3 | 7 | 1 | 6 | 0 | 1 | 1 | 0 | 3 | 0 | 1 | 23 |
| *Astare undata* | 7 | 16 | 7 | 7 | 7 | 6 | 4 | 9 | 12 | 4 | 4 | 83 |
| *Cyclocardia borealis* | 2 | 11 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 15 |
| *Arctica islandica* | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Cerastoderma pinnulatum* | 18 | 36 | 9 | 15 | 3 | 11 | 0 | 1 | 1 | 4 | 7 | 105 |
| *Pitar morrhuana* | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Ensis directus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Mya arenaria* | 12 | 11 | 10 | 21 | 1 | 25 | 3 | 5 | 2 | 0 | 5 | 95 |
| *Mya truncata* | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Lyonsia hyalina* | 4 | 7 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 15 |
| *Periploma fragile* | 8 | 10 | 8 | 8 | 6 | 6 | 2 | 2 | 4 | 7 | 2 | 63 |
| *Thyasira flexuosa* | 12 | 19 | 6 | 19 | 7 | 10 | 0 | 1 | 3 | 1 | 5 | 83 |
| *Crystallophrisson nitidulum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| Ostracoda | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |

| Binomen | LKROCT | LKRNOV | LKRJAN | LKRFEB | LKRMAR | LKRAPR | LKRMAY | LKRJUN | LKRJUL | LKRAUG | LKRSEPT | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pseudoleptocuma minor* | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 2 | 4 | 3 | 0 | 13 |
| *Diastylis quadrispinosa* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 1 | 8 |
| *Diastylis sculpta* | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 6 |
| *Edotea montosa* | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 5 |
| *Corophium bonelli* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Corophium crassicorne* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 |
| *Erichthonius rubricornis* | | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Photis macrocoxa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ischyrocerus anguipes* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 4 |
| *Monoculodes tesselatus* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 3 |
| *Westwoodilla sp.* | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| *Harpinia propinqua* | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Metopella angusta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Dyopedos monacanthus* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Caprellidae | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| *Maera danae* | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Crangon septemspinosa* | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 3 |
| Phascolion strombi | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Biomass (gm) | 15.14 | 4.771 | 4.318 | 3.283 | 11.7 | 10.015 | 1.801 | 7.155 | 3.99 | 2.667 | 2.498 | 4761 |